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THE

TOPOGRAPHY AND GEOLOGY

OF THE

DISTRICT BETWEEN CAIRO AND SUEZ

By

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PREFACE.

This district was first examined by Mr. L. Leigh Smith during the winter season of 1896-97, Mr. F. W. Green acting as topographer. At the end of that season, Mr. Smith resigned his post as geologist and went back to England. When the map of the district came to be compiled, it was found that there were several places where re-examination was necessary and in other parts revision was required. Accordingly, this was undertaken in the winter season of 1901-02, and was completed during the months from December to the end of March.

The original map sheets prepared by Mr. Green were used as the basis for the revision, a plane-table being taken for the purpose of fixing the geological boundaries and filling in any part of the topography which was incomplete. In putting in small pieces of topography or geology a 20-metre chain was used, while the relative heights above sea-level were determined by an aneroid previously adjusted at the Government Observatory at Abbassia. No meteorological observations were made as no instruments were taken on the expedition.

Specimens of the different plants were not collected because the majority of them belonged to woody varieties and consequently did not press well. The local names by which they were known to the Bedawin were taken in all cases. At the time the work was done only a few plants were in blossom, while the majority, owing to a lack of moisture, was in a dried up condition.

The naming of the fossils collected was undertaken by Dr. Blanckenhorn and Dr. Jannensch.

The memoir is mainly geological; a chapter on the topography and natural history of the district is placed at the beginning, followed by a detailed account of the geology and tectonics, the vulcanicity and thermal action which have in different ways influenced the general relief of the country.

A chapter on the abrading power of the wind and sand in this district is also given.

T. B.

Cairo, 1904.

Note. Owing to the lamented death of the author of this memoir, it is printed direct from the manuscript as left by him.

THE TOPOGRAPHY AND GEOLOGY

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DISTRICT BETWEEN CAIRO AND SUEZ.

CHAPTER I.

TOPOGRAPHY.

THE district described in this memoir is that bounded on the north by the wide plain which commences a little to the north of Abbassia and extends towards Ismailia where it joins that of the Isthmus of Suez which is continuous to the town of Suez, and on the south by that line of escarpment which begins at Gebel Tura and ends on the Gulf of Suez in Gebel Ataqa. The western boundary is the Nile Valley.

Starting at Abbassia from the cantonments of the Egyptian troops, the traveller sees the old disused Post-Road to Suez running away in a north-easterly direction. Following this, on the right is seen the prominent red hill of Gebel Ahmar, behind which is the small, triangular plateau of Gebel Moqattam, bounded on three sides by cliffs, but on the fourth becoming gradually merged into the rising ground to the east. To the north of the Moqattam the country is covered by a confused mass of sand, gravel, and limestone ridges separated from each other by narrow steep-sided drainages which make movement from place to place a matter of great difficulty. This type of country extends beyond the Post Road to the north, and eastward as far as station No. 5 on this road, Abbassia being reckoned as No. 1.

The drainage of this area goes out in a north-westerly direction, but the wadis are so short and insignificant that the Bedawin have not given any distinctive names to them. The watershed lies roughly on a line joining the north side of Gebel Moqattam and Gebel Amuna, and then extends to a point about 5 kilometres east of Gebel Um Qamr. Except one drainage subsequently to be mentioned, all the water from this area passes out into the Birket el Hag, near Abbassia. The only drainage which passes out in another direction takes its origin on the northern limits of the little Petrified Forest, and falling in a north-westerly direction receives the drainage from the small wadi in which En Musa is situated, as well as other smaller wadis draining the north side of the Moqattam along the foot of which it flows, finally passing out at Gebel Ahmar. On its north, it receives scarcely any affluents, except opposite the wadi in which En Musa is situated. In the early part of its course the fall is rapid, but further down the slope is more gentle, and is marked by numerous bushes of "bawal," *Zygophyllum album.*

Of the drainages which pass out towards the Birket el Hag, the most westerly takes its origin amongst the low gravel hills near the head of the previously mentioned water-course, in a number of small drainages which gradually become fused into one, and passes out in a shallow-sided wadi a little to the west of Station No. 2, Old Post Road to Suez, running in a north-westerly direction towards the Nile Valley.

The next drainage line heads in the gravel hills to the west of Gebel el Angobia, and trending in a northwesterly direction strikes the Old Post Road to Suez a little to the west of House No. 3; running parallel to it for some time, it crosses it at the foot of the ridge on which House No. 2 stands, and flows in the direction of the Nile Valley. Further east, another water-course also takes its origin amongst the gravel hills near Gebel el Angobia, and running in a northerly direction round the east foot of Gebel Ansuri passes out east of House No. 4, Old Post Road to Suez, towards the valley which leads down to the Birket el Hag.

The main drainage line of this basin is the valley above mentioned. From the line joining Gebel Amuna and a point about 5 kilometres east of Gebel Um Qamr which is the water-parting between this basin and that of Wadi Gafra, this wadi collects the water from both sides, and flowing west discharges into the Birket el Hag. In this valley are several large sand-dunes the long axes of which lie in a N.W.-S.E. line, thus showing that the sand-drift is from the south-west, as the long slope of the dune was in this direction. These dunes are called "Kataban" by the Bedawin. It is up this valley that the disused railway to Suez runs.

In this basin there are only three hills which have received distinctive names. These are Gebel Dhaher, Ansuri, and el Angobia. The first is a black ridge on which House No. 3, Old Post-Road to Suez, stands; the other two are parts of a breached dome of Eocene rocks, Gebel el Angobia forming a steep scarp facing north-west, and falling away at a gentle angle in the opposite direction, while Gebel Ansuri presents an abrupt face to the south-east with a gentler slope to the north-west.

Gebel el Angobia is prolonged in a long narrow ridge which gradually loses itself in the gravel-topped hills of the Miocene area. It is really an inlier produced by two lines of fault. In the small wadis which drain it water occurs in "pot-holes" at certain times of the year.

To the south of the line joining Gebels Moqattam and Amuna the country falls to the south, the drainage passing out in the valley between the Moqattam and Gebel Tura, which is known as the Bahr Bela Ma, and discharges its water into the Nile Valley a little to the north of Tura. This district offers many difficulties to a traveller crossing it from east to west, in the numerous valleys and ridges of gravel and sand which are often thickly covered by silicified trunks of trees, sometimes of great length. This is the Petrified Forest, and is known as Gebel Khashab by the Bedawin.

By the side of one of the drainage lines where it enters the Bahr Bela Ma, is a shaft sunk in the limestone and known to the Bedawin as Bir el Fahm. This is said to be a shaft sunk during the time of Ismail Pasha in a search for coal.

Gebel Khashab may be said to extend practically to the foot of Gebel Amuna or Gebel Ali Hamum el Azraq. In all the small valleys in this area numerous small bushes of various kinds are found which will be noticed in a note on the plant life. Among the more common plants are "Shia" (*Artemisia judaica*) "Bsilla" (*Zilla myagroides*) and "Arta" (*Calligonum comosum*).

A few bushes of "Markh" (*Leptadenia pyrotechnica*) and one or two stunted "Seyal" trees (*Acacia tortilis*) are also found. Much spear-grass, known to the Bedawin as "Ithmum" and "Dahram" occurs in the wadis and is eaten by the numerous herds of camels which are met with in this district. "Retem" (*Retem roetama*) also occurs in the dry water-courses.

As the eastern watershed is approached the country becomes a maze of gravel ridges and hills in which it is extremely difficult to move about, there being no main drainage line in which an easy path is found. It is an alternation of ridge and gully extending for kilometres, and the pebble-covered surface is extremely trying to walk over. Dominating this area are two higher hills which stand out from the surrounding ridges, viz., Gebel Ali Hamum el Aberaq and Ali Hamum el Azraq or Amuna. The latter is a well-marked round hill of a peculiar purplish colour in certain lights, hence its name; the former is a brownish rounded hill somewhat flatter topped than Amuna and the two make well-defined landmarks.

After crossing the ridge of which these hills form the main summits, a different type of country is entered. This is the basin of Wadi Gendali. It is bounded on the south by the limestone wall of Gebel Qatamia and Um Thibua, on the east by Gebel Awebed and the low ridges on either side of that range, on the north by the gravel and limestone ridges which lie east and west of the ruined palace of Der el Beda and on the west by the gravel ridge of Gebel Amuna and Ali Hamum el Aberaq. It may be described as a plain in which isolated hills occupy the western half, this part being cut off from the more open eastern half by a ridge of limestone having its scarp facing the north-west, and its dip-slope falling gradually to plain-level in the opposite direction. This ridge is known as Gebel Rieshi. The south-western part of this basin consists of terraced hills and ridges of Eocene rocks amongst which the Wadi Gendali takes its origin.

Although this has been described as the basin of Wadi Gendali, strictly speaking it is not entirely so, as the drainage from the ground between Gebel Rieshi and the gravel ridge of Ali Hamum el Aberaq passes out northwards in two or three shallow, more or less parallel, water-courses into the wide valley which drains westwards into the Birket el Hag. The hills from Gebel Amuna south and west send all their water into the Wadi Gendali.

Wadi Gendali. This wadi takes its origin amongst the low terraced hills which extend to the foot of the plateau of which Gebel Tura and Gebel Hof form a part. Down to the point where Bir Gendali occurs, it is a collection of smaller feeders converging into one, and it is only about a kilometre above the well that it becomes a well-defined wadi. Here it receives feeders from Gebel Amuna and its foot-hills, as well as from the low limestone hills which lie to the north-west and north of the wells. From the wells, after falling over a low precipice of limestone, it flows in a north-westerly direction in a broad shallow valley from 100 to 150 metres wide, full of bushes of "Shia," "Retem," "Tarfa," "Arta," "Gharqad," "Qataf," and "Ushad." After running between low hills for 8 or 9 kilometres, the ground to the north opens out leaving a sort of enclosed space called Akheshan by the Bedawin; the eastern limit of this place is a prominent red hill, the neck of an ancient geyser, and after passing it the wadi opens out into the plain, runs along the foot of Gebel Rieshi and enters Wadi Gafra a short distance to the east of Der el Beda. As far as can be seen this is a case of the same wadi having different names in different parts of its course. It may be, however, that the Wadi Gendali is regarded as ending at the gorge known as Atheiga el Gafra, where the whole of the drainage of this plain passes through the limestone ridge, because at this point the water-courses from all sides meet, and they may be thus looked upon as tributaries converging together to form the Wadi Gafra. This wadi is by far the largest drainage in the district.

When visited this wadi was the centre of one of those severe thunderstorms which occasionally break over the desert in this region. During the march to it, the day was very oppressive, and large thunderous-looking clouds hung all round. In the evening the appearance of the sky was so threatening that it was decided not to camp in the main wadi but in a side valley where there was a piece of ground above the general level of the water-course. Shortly after the tents had been pitched the storm broke overhead, rain falling in torrents. In less than an hour, the valley was a wild muddy torrent, while the higher ground was so full of water that it was practically a quagmire. The rain fell steadily for about four hours; every little gully was running full; and after darkness fell, the air was full of the sound of the numerous waterfalls with which this district abounds. It was two days before the ground had dried sufficiently to allow of the camels carrying loads over it, and even then they sank a good deal in certain places.

After the wadi was sufficiently dried to allow of camels walking along, an excursion was made to the point where it opens out into the plain. It was then seen what havoc had been done by the storm; the floor of the valley was crossed in all directions by deep furrows hollowed out by the water; numerous bushes were uprooted and lying in these furrows; while many others were seen hanging by only a few roots, and what was before the storm a fairly fertile wadi yielding food for numerous sheep, goats and camels, now presented a dreary picture of desolation, the vegetation which had not been swept away being buried in mud and sand.

Bir Gendali

There are in reality three wells, but one is so much more important that the others are generally not counted. The other two occur further to the south and do not contain so much water as the more northerly one. They are dug in a marly clay which forms the bed of the wadi at this particular point. The most important well was, according to the Bedawin, sunk by Ismail Pasha for the good of the people. Near it are the remains of a galvanised iron hut which was erected by the men in charge of the work. A ruined windlass for raising and lowering a bucket for lifting the water is still seen at the well. According to the Bedawin, the quality of the water varies considerably according to the season of the year. In the winter when there is some rainfall, it is very fairly potable, but during the summer and autumn it is very salt and bitter. When visited by the writer it had a green stagnant appearance and was not at all pleasant to the taste, and the Bedawin stated that it was only after the other water-supplies failed that they came to Bir Gendali.

The plain to the east of Wadi Gendali is drained by several water-courses which flow in a north or north-westerly direction until they are deflected by the ridge which extends in an easterly direction from Der el Beda. The most easterly of these receives the water from the west end of Gebel Ataqa, from Um Thibua, and the south side of Gebel Awebed. They then run parallel to it until they meet Wadi Gêndali with which they fuse and form Wadi Gafra.

Wadi Gafra.

From the point where Wadi Gendali and the other drainages unite the wadi takes the name of Gafra. It then passes the limestone ridge by the narrow gorge known as Atheiga el Gafra, and after passing the old railway embankment, bends round and wends its way in a north-westerly direction through a maze of low gravel hills and along the foot of Gebel Gafra towards the wide plain or "Hammad" which it enters by a well-defined valley through the limestone ridge forming its southern boundary about 11 kilometres east of Gebel Um Qamr, thence making its way to the cultivation at Bilbeis. This is perhaps the most important drainage in all the district.

To the south of Atheiga el Gafra is a small bend in the side of the wadi which acts as a natural reservoir for water in time of rain. It is filled by sand, and the water filters slowly through into the holes scooped out by the Bedawin who come from far and near with their "qirab" or waterskins to have them filled. This takes practically a whole day, and while the pools are slowly filling the people exchange news and discuss the current topics of the day.

On the north side of the pass between the old railway embankment and the limestone ridge there are one or two trees, and the ground is very fertile judging by the well-grown plants. The water passing down Wadi Gafra must have been dammed up by the railway embankment and formed a pool, but since the railway was abandoned, it has breached it and has now a clear way. Near here are the remains of some old huts which were probably occupied by the railway employés. From this point down to the passage out into the plain, the Wadi Gafra is filled with plants of "retem," "ithmum" and "bsilla" which afford food to numerous camels, as well as gazelle. While in this wadi, the writer saw a herd of eleven gazelle.

The country round Wadi Gendali and Wadi Gafra.

Near the head of Wadi Gendali and round Bir Gendali the country is a low plateau sloping south-west towards the higher limestone plateau which lies to the east of Tura and Helwan. It is formed of yellow marly limestones and clays which on account of their unequal hardness give rise to a terraced appearance. On the north this is bounded by low rounded gravel hills, while to the east the ground gradually rises to the foot of the plateau of Gebel el Qatamia and El Thele. The ridge in which Atheiga el Gafra is cut is made of limestone backed by a mass of gravel mounds. The limestone ridge extends from near Der el Beda to the foot of Gebel Awebed, but the gravel ridges and mounds extend from near Station No. 6, Old Post Road to Suez, up to the foot of the same hill. The limestone ridge slopes to the north and soon loses itself in the plain.

On the top of the gravel ridge a little to the south of Atheiga el Gafra, and quite close to the Old Post Road to Suez, stands the ruined palace of Der el Beda. This was built by Ismail Pasha as a summer resort, and forms a landmark in the surrounding district. A road from the Old Post Road to Suez goes up to Der el Beda, while a station on the Old Railway to Suez was not very far from it. According to the Bedawin, the palace drew all its water supply from the reservoir at this station, camels being employed as the means of transport. All the floors in the building have been thoroughly dug up by the Bedawin in search for hidden treasure which they firmly believe is buried there. **Der el Beda.**

Following Wadi Gafra across the plain or wide valley, the water-course runs along the foot of a hog-backed ridge known as Gebel Gafra. It slopes at a fair angle to north and south, its highest points being gravel and sand hills which are seen for a good distance, while at its western end is a dark, conical peak of limestone which is also recognisable at some distance. To the north-east it slopes down to the foot of the limestone cliff of Miocene age, which in its turn slopes towards the foot of Gebel Gafeisad or Agleiat Qamr. To the east Gebel Gafra slopes gradually until it becomes merged into a confused mass of gravel hills which disappears in the plain. **Gebel Gafra.**

On the west side of Wadi Gafra, opposite Gebel Gafra where the wadi passes out into the plain, is a mass of rounded gravel hills, which when followed westward gradually become replaced by limestone. At the point where the gravel ceases there is a prominent limestone peak named Um Qamr which, standing on the skyline in this region, is a useful point for checking the position while traversing round it. The ridge on which Um Qamr occurs forms the northern side of the valley previously mentioned which carries the drainage down to the Birket el Hag. It slopes gently down to plain-level on the north (this being due to the eroding action of the wind and sand) and ends in a low terrace on the south from which the ground gradually slopes into the valley. Separated from this by a drainage line is a small roughly-triangular mass of limestone having an escarpment facing the north and north-west, and gradually sloping southward toward the valley. On the east side it gradually becomes merged into the higher ground, a fault having let it down at this point.

Gebel Gafeisad or Agleiat Qamr.

Leaving Wadi Gafra, and passing along the plain to the north of Gebel Gafra a low black hill is reached which is known by the dual name of Gebel Gafeisad or Agleiat Qamr. The latter name seemed so peculiar that the writer enquired of the Bedawin how the name was given. In reply he was told a story the details of which would not bear printing but is almost an exact replica of that of Samson and Delilah with a different ending. Gebel Gafeisad is a volcanic neck in which a geyser had subsequently formed, the hard silicified plug now standing out in relief from the top of the hill On the north side the hill falls abruptly to the plain, but on all the other sides it slopes gently into the surrounding country. On account of its low altitude this hill is not a prominent object in the landscape.

Gebel el Gherbe.

Passing eastward from Gebel Gafeisad, a low mass of gravel and sandy hills is traversed in which numerous stumps of small geysers occur. This area of gravel and sand disappears under a limestone ridge which gradually rises eastwards, and ends in a well-marked dark peak named Gebel el Gherbe. This ridge presents the more abrupt face to the south, and slopes gradually until it is merged into the plain. On the south side the drainage of the ridge and the low-lying ground to the south, as well as the limestone area on the south side of this low ground, is collected into one single water-course which likewise drains the gravel hills to the east of Gebel Gafra, and afterwards passes through the ridge on the north by a "Moqta" (1) a little to the east of Gebel Gafeisad. It afterwards makes its way across the plain towards the cultivation.

This drainage is known as Wadi Abu Awasih by the Bedawin. In it at certain periods of the year there is a well at the "Moqta" where it passes out into the plain.

To the east of the watershed of Wadi Gafra the low ground ceases to be a valley such as it is to the west, and is now more or less a plain studded with isolated knolls of limestone. From that point also the drainage passes out in a north-westerly direction.

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(1) The Bedawin use the word "Moqta" to denote the place where a wadi passes through a ridge with gently sloping low sides. If it is a gorge like that of Wadi Gafra it is known as "Atheiga."

In the immediate neighbourhood of El Gherbe, on the east side, the country is covered by low gravel hills. Further east the country begins to assume the terraced appearance which is so marked later on. On the edge of the plain or "hammad" which extends to Ismailia, the rocks have been planed down by the wind and sand until they simulate a dip-slope, and appear to be dipping into the plain. Starting from the plain the observer walks up this slope until he arrives at the top of the terrace; he then descends the escarpment of the ridge, crosses a shallow valley and again ascends the escarpment on its further side when he again finds himself on a terrace. Going southwards he descends slightly for a while until an area of gravel and sand is reached which forms a slight rise and eventually slopes gently to the foot of the escarpment of the limestone plateau which dominates the country at this point. This description holds good for the country as far as Gebel Shabrawet. The limestone plateau above-mentioned has a well-defined escarpment facing north and north-east; it gradually falls to ground-level on the east and west sides, as its slope is to the south-west in the direction of the plain of El Geluf north of Gebel Awebed. This is not a dip-slope as would at first appear, but has been produced by the eroding action of the wind and sand. At its south-east corner it forms a bold headland which has been named Fuchsberg by Dr. G. Schweinfurth, but it bears no distinctive name amongst the Bedawin.

The terraced appearance of this district is the direct outcome of geological causes as they in every case owe their origin to lines of fault which have let down the rocks to the north.

The drainage of this area passes out mainly on the west side by three small wadis which unite to form one drainage line in the plain to the north. A small wadi heading in the high plateau passes out into the plain on the west side of Gebel Shabrawet, in the direction of the Bitter Lake.

Gebel Shabrawet

This is a well-marked dark hill of highly tilted strata standing by itself at the entrance to a wide drainage line. It is about 224 metres above sea level, and rises abruptly on all sides, but on the west face is a precipice. On its north-west side the terrace which overlooks the plain slowly runs down to ground level; while on its south and west sides the plateau of Eocene limestone faces it in an abrupt scarp 115 metres high.

To the south of Gebel Shabrawet the terraced appearance of the country is very marked, but whereas on the west side of this hill, the first terrace sloped gently to the plain, on the south it rises with an abrupt escarpment out of the plain. Here it is capped by gravel and sand, while between it and the next there is a small wadi formed along the line of fault. The second terrace is a replica of the first, both of them sloping westward towards the foot of the main limestone plateau.

As Gebel Genefe is neared the terraced character becomes lost owing to the dying-out of the faults which gave rise to it. The main drainage-line of this district heads in the Fuchsberg of Dr. G. Schweinfurth and descending eastwards collects all the various smaller drainages from either side and eventually makes its way into the plain where it loses itself.

Gebel Genefe. This is a limestone plateau sloping west and south and presenting a bold escarpment to the north-east and east inaccessible in many places, especially towards the north, but becoming less steep as it is followed to the south. The rugged cliff on its north-east side gradually falls to the west, and eventually becomes merged in the low cliff which is the product of a north-and-south fault. As the surface of Gebel Genefe is traversed westward, the gradual slope is interrupted by low scarps of limestone outliers capped by gravel. These gradually sink to plain-level and disappear under the limestone plateau to the west.

At the east foot of Gebel Genefe are a few low ridges of limestone which have been faulted down from above. Here also on a low terrace of gypseous marl stand the offices and dwelling-houses of the Genefe Company which was formed to work the alabaster and other stone which occur in the plateau and cliff. A railway embankment still exists on which a branch-line from Genefe Station was laid, by means of which stores were run up to the workmen there, and the quarried material sent to its destination. The Company has not been working here for several years.

Following this plateau southwards it is seen to gradually slope down and disappear under the sand and gravel hills which occupy the country between Gebel Genefe and the plain of El Geluf. Viewed from an eminence, this country presents a curious striped undulating appearance due to the alternation of ridges of limestone and gravel; it slopes gradually from the foot of Fuchsberg to the valley which carries off the drainage from Gebel Ataqa.

Gebel Awêbed. This is an isolated high hill of limestone bounded on three sides by more or less precipitous cliffs, and standing in the plain about 15 kilometres south-west of Fuchsberg. It is 9 kilometres long by 3·5 kilometres wide at it widest point, its long axis lying east and west. At its highest point it is over 600 metres above sea-level. It owes its origin to a fault which has let the country down on all sides. The drainage from this hill pass down its sides in a series of cascades. Part of that from the south passes off in a south-easterly direction towards Suez; while the other makes its way into Wadi Gafra.

On the north side the water passes out in a north-westerly direction by way of Wadi Abu Awasib, the drainage line which falls out a little to the east of Gebel Gafeisad. It is thus seen that Gebel Awebed stands on the watershed between the Mediterranean and the Gulf of Suez.

On the south of this hill there occur one or two natural caves which have been inhabited by hyenas at an earlier period, as is evidenced by the number of big bones which have been carried there and gnawed by these animals.

Gebel Um Thibua. To the south of Gebel Awebed, and separated from it by a plain about 15 kilometres wide, is Gebel Um Thibua, which forms part of the plateau wall bounding the district under description. It is bounded on the north and east by precipitous cliffs which are almost unscalable, and its surface falls to the south at a gentle angle. Its highest point stands over 600 metres above sea-level. Between it and the west end of Gebel Ataqa is a small watercourse which discharges its water eventually into Wadi Gafra. Up this valley is a path which leads over the watershed to Wadi Ramlia.

Gebel Ataqa. This range begins on the east side of the small watercourse which separates it from Gebel Um Thibua. From this point it extends in an easterly direction until the highest peak is reached whence it bends round to the south and ends on the sea-coast, its total length being between 35 and 36 kilometres. At its most westerly extension it begins at ground-level and gradually rises until at its highest point in the headland facing Suez it attains 900 metres above sea-level. Taken as a whole Gebel Ataqa may be regarded as a plateau sloping to the south-west and much cut up by narrow, steep-sided watercourses. To the east or north-east it presents a steep, rugged cliff which is unclimbable except at certain places. The drainages descend from the plateau by a series of water-falls, and make their way to Suez along the main waterway which runs parallel to the range along the low ground where the foot-hills composed of boulders and gravel end.

From the main headland, where the range bends round to the south, there extends westwards for 11 kilometres a low, secondary plateau which is the result of faulting. At its foot are the foot-hills or low plateau composed of boulders and gravel above-mentioned. The main headland of Ataqa presents an imposing appearance. At the foot it can be climbed for about 300 metres, but from that point the cliff rises vertically for 400 metres, and ends in a rugged frowning precipice of hard, flinty limestone. From this point to the mouth of the wadi which drains the east side of the plateau near the seashore, the range presents the same rugged and forbidding appearance; but to the south of this the cliff becomes less difficult owing to a secondary ridge having been faulted down against it, and also to its gradually becoming lower as it is followed to the south.

Along the watercourses and in the plain many species of Geraniaceæ, "shia" (*Artemisia Judaica*), "rabl" (*Pulicaria undulata*), and "lasaf" (*Capparis spinosa*, var. *Aegyptia*), are found.

Roads.

The various camel roads which were at one time in use between Cairo and Suez have been largely abandoned in favour of the Old Post Road to Suez, which offers much easier going and a much more level path. Of the old roads one starts from Abbassia, and after following the course of the Post Road for some time, strikes off towards Gebel el Angobia and south-east through the gravel area towards Gebel Awebed which it passes on the south side and thence through the drainage line to Suez. A second road passes through the Petrified Forest, over the gravel hills towards Gebel Awebed, and joins the previous road.

A third road comes from Bilbeis up the Wadi Gafra and, leaving it near the Old Railway, runs parallel with the latter as far as Gebel Awebed, whence it diverges a little to the north, passes through the gravel area into the watercourse which descends from Fuchsberg, and goes on to Suez.

Disused Post Road.

This is a road which was made for the conveyance of mails and passengers from Cairo to Suez, before the opening of the Suez Canal. It was a properly macadamised road, the stones required for the work being obtained from the hard siliceous limestones which occur near the road. It is still marked by low mounds of sand which were intended to keep the water off it in places, but the road itself for the greater part is now buried in sand. Starting from Abbassia the road runs in a fairly straight course east and west. Between Abbassia, which is counted as No. 1 station, and Station No. 2 (Shohob), the road has now been practically destroyed by down-wash and sand-drift; it is also on an up-gradient. From Shohob the road descends a steepish hill into a watercourse which has cut a deep rut in it, from whence it goes by a gentle rise to Station No. 3 (Dhaher) where it has been embanked to save cutting a ridge at this point. These two stations have signal towers on the hill tops from which notice of the approach of the mail could be signalled. From Dhaher the road passes along the low ground to Station No. 4 (Ansuri) and on to No. 5, which also stands in the plain and is known as El Angobia. From this station the road goes up and down over ridges to Station No. 6 (El Fum) whence it eventually enters the large plain which extends to Gebel Awebed. The next station No. 7 is known as Adabba, the latter and Station No. 8 (El Managa) lying near the foot of a gravel ridge which extends to the ruined palace of Der el Beda, opposite which is Station No. 9 bearing the name of El Hamra. Further east across the plain, Station No. 10 (El Dakruri) is reached; it receives its name from the tomb of Shekh Dakruri which stands about 2 kilometres further west. The next station No. 11 (El Hafeira) lies in the plain opposite the west end of Gebel Awebed, while No. 12 (El Shoaria) lies opposite the eastern extremity of that range. From Station No. 9, the road has been running along the plain bounded on the south by the limestone cliffs of Gebel el Thele, Qatamia and Um Thibua, and on the north by the gravel hills to the east of Der el Beda, and by Gebel Awebed. Station No. 12 stands on the east side of the watershed which separates the drainages passing into the Gulf of Suez and the Mediterranean respectively. From this point the ground falls eastwards and when Station No. 13 (El Bahara) is reached it is found to be in the main drainage line. The next station is No. 14 (El Agrud) and stands near the ruined fort of that name; from this point the road strikes across the plain in the direction of Suez, the next station being No. 15 (El Ugrat Samra). Station No. 16 (Bir el Gazmal) is the last stage before Suez is reached. Here the various roads converge before entering Suez, and in earlier days the people on pilgrimage to Mecca used to encamp at this well. On this road there were therefore fifteen stages between Cairo and Suez. Certain of the stations were larger than others and seemed intended for the accommodation of passengers for the night, but whether the post ran by night as well as by day the writer could not ascertain.

Story of hidden treasure.

Amongst the Bedawin there is a story told about the mail-coach being surrounded near Agrud and the mails, which contained a large sum of money, being carried off. Attempts were made by the Government to find the thieves but without avail, and the money has never been recovered. It is stated to have been buried somewhere in the neighbourhood of Gebel Awebed, but no one knows the exact spot, as the original perpetrators of the robbery are now dead.

The Old Post Road to Suez is known by the Bedawin as the Sikkat el Samuel from the name of the engineer who superintended the making of it.

Disused railway to Suez.

This line started from Cairo a little to the north of Abbassia and, following the main valley which drains the western part of the district, passes across Wadi Gafra where it has a fairly high embankment and, before reaching the half-way station, enters a cutting which passes through a hill of limestone and conglomerate.

From the middle station the railway winds about, avoiding the obstacles in its way as much as possible, and passes along the plain to the north of Gebel Awebed opposite which is Awêbed Station. From this station the line enters the gravel hills and winds in a tortuous fashion amongst them until it approaches El Agrud from which point it passes across the plain to Suez. There were four stations in all between Cairo and Suez. The first stands near the sand-dunes mentioned earlier in this report; the second or half-way station, lies to the north of Der el Beda; the third is opposite Gebel Awêbed; and the fourth at El Agrud.

The first and third stations have been mere stone huts; but the second seems to have been much more important. There is a well-built house and platform, and underneath the latter is a reservoir for storing water. On either side of the platform are cement troughs which open into the reservoir, and water-tanks were brought alongside on rails and emptied there. This seems to have been the most important station on the line.

Along the line at various stations are the ruins of huts which were occupied by the men employed on the line.

Animal life.

During the season of the year in which this district was visited not many animals were seen. It may be that the more timid animals have been driven away by the large numbers of camels which wander at will over the ground. Gazelle were seen at various times and places, in one instance as many as eleven being seen together. The Egyptian hare "Arnab" (*Lepus* (?) *Egyptiaca*) was frequently put up from the tussocks of grass which are so common in the wadis, while one was actually started out of a heap of stones which had been taken from one of the quarries in the Moqattam. The "gerbil" was a frequent visitor in the tent, and when once in was with difficulty evicted. Snakes were not very common, only one or two specimens of the horned viper being noted, while a long green snake of a non-poisonous type was once seen.

During the early part of the year of 1902, numerous large birds named "kark" by the Bedawin and resembling the stork at a distance, were often seen. They seemed to come from the fields and settle in the desert but they were extremely shy, and would not allow any one to approach them. They were only noted for a certain time and afterwards disappeared; it is thus probable that they were migrating.

The different plants met with have been as a rule mentioned by their local names when describing the district in which they were found.

Certain plants such as "lasaf" were only met with at one place; but the majority of those mentioned are common to the district. The following is a list of the plants found and arranged in their Natural Orders:—

No.	ORDER	GENERA AND SPECIES	BEDAWIN NAME
1	Cruciferæ...	Zilla myagroides	Bsilla.
2	Capparidaceæ	Capparis spinosa var. Aegyptia	Lasaf.
3	Paronychiaceæ ...	Gymnocarpum fruticosum	Garad.
4	Tamariscaceæ	Tamarix nilotica	Tarfa.
5	Zygophyllaceæ ...	Fagonia latifolia	—
6	"	Seltzenia orientalis...	—
7	"	Nitraria retusa	Gharqad.
8	Papilionatæ	Astragalus leucacanthus	Kadak.
9	Mimosaceæ	Acacia tortilis...	—
10	Umbelliferæ	Zozimia absinthifolia	—
11	—	Pityranthus triradiatus...	Qasukh
12	—	" tortuosus	Saqukh.
13	Rubiaceæ...	Gaillonia calycoptera	—
14	Compositæ	Echinopus spinosus	Khashir.
15	"	Pulicaria undulata...	Rabl.
16	Campanulaceæ ...	Campanula sulphurea	—
17	Solanaceæ...	Lycium arabicum	Ushad.
18	Labiatæ	Otostegia microphylla	—
19	Salsolaceæ..	Traganum nudatum	Hamd.
20	"	Anabasis articulata...	Agram.
21	"	Atriplex halimus var. Schweinfurthi...	Qataf.
22	Liliaceæ	Allium crameri	—
23	"	Urginea undulata	—
24	Graminaceæ	Panicum turgidum...	Ethmam.
25	Gnetaceæ...	Efreda alata	—

Beside these many others would doubtless have been found if a special search had been made for them, but, as the time was devoted chiefly to examining the geology of the district, only those plants which caught the eye easily were noticed.

The inhabitants of the district are Bedawin belonging to the tribe of the Hawatat. They are very quiet and inoffensive in their nature, but full of curiosity about strangers.

The people of the district.

Amongst themselves it seems to be looked on as an accomplishment to be a past-master in the art of lying, if one may judge from the trials of skill which take place between men who are unknown to each other. The one tries to get information by cunning questions while the other baffles him by evasive or untrue answers.

Their main means of livelihood is the breeding of camels, for which the country and the wide plains along the edge of the cultivation are well adapted. Roaming all over the plains are large herds of she-camels, which at the time the survey was made, were close to the time of foaling. Some had already brought forth their young, while day by day others were dropping their offspring. At this time the owners wander about looking for those females whose time is expired, in order to assist them if necessary, or to bring the mother and young one into a sheltered place where food is fairly plentiful, so that they can give an eye to them until the young camel can manage for itself. It is not an uncommon sight to see a man carrying a young, newly-born camel on his shoulders with the mother following close at his heels, a look of intense mother-love shining in her eyes. Except at this time and the mating season, the camels are no trouble to their owners, for as soon as the female has been served by the male, she is turned adrift and left to look after herself, unless the food-supply fails, when the herd is taken to another place. From what the people said, it appears that the camels can as a rule look after themselves as far as water is concerned. If the prices mentioned as being obtained for camels at the various fairs are correct, viz.:—L.E. 5 for a camel rising four years old, it is difficult to see how it can be a lucrative pursuit. As far as food is concerned the expense is *nil*, but as the people only expect a camel to bear once in two years it seems as though the profits must be extremely small.

A fair number of donkeys are likewise kept by the people, but they are mainly kept as beasts of burden and not so much for breeding purposes. In a conversation with some of the people, a curious fact was elicited, viz. :—that their donkeys were only taken to drink every three or four days. This seems incredible at first sight, but it was after seeing these animals going about in an absolutely waterless district that the writer asked how the donkeys were provided with water, when the information stated above was given. It shows to what training can accustom an animal.

One other thing which marks these people off from Bedawin generally is their habit of keeping their water in old petroleum tins rather than in the waterskins or "qirab" used by all others. This may be due to their coming more in contact with civilisation than those further south and west.

Sheep and goats are also kept in this district but not in such numbers as elsewhere.

CHAPTER II.

PLEISTOCENE AND RECENT.

Of these deposits, only very few occur in the district under description. It may be said, of course, that all recent deposits in the wadis, etc., ought to be included, and in that case these beds may be said to occur all over the area. Only the places will be described however, where these deposits occur in any appreciable thickness.

The first place to be mentioned is the area to the east of Abbassia, where the country is masked to a large extent by a down-wash of sand and pebbles from the Oligocene and Eocene beds further to the east. Here also the Miocene beds are in places completely masked by a mixture of sand, earthy material, and sub-angular pebbles. To the north and west of Stations Nos. 2 and 3 of the Old Post Road to Suez, the older beds are entirely covered by this gravelly deposit.

In the vicinity of El Angobia and Gebel Ansuri, the relations between the different beds are often obscured by these gravelly beds.

Between Bir Gendali and Gebel Rieshi, there are gravel and sand deposits capping isolated knolls of Miocene to the thickness of 5 metres.

Gebel Shabrawet.—The place, *par excellence*, where these beds seem to be best developed, is in the area occupied by Gebel Shabrawet and the black knoll of Cretaceous limestone about 4 kilometres to the west. Here the space between the Miocene escarpment on the north-west and the Eocene cliff on the south and east is occupied by a series of hills, rather steep-sided and difficult to climb, representing what was a continuous deposit of Pleistocene beds. No fossils have been found in them but these deposits are later than the formation of the Isthmus, or, to be more exact, have been formed when the Isthmus was under water. These deposits are between 50 to 60 metres thick, and consist, as far as can be seen from their masked appearance, of limestone conglomerates on the top, with sands and clays containing pebbles at the bottom. These overlie a ridge of Cretaceous limestone.

At the foot of the Eocene cliff opposite Gebel Shabrawet, these beds are better exposed and a section was measured of which the following is a detailed account:—

Top.	Consolidated sand with boulders of Eocene limestone in it	1·6 metres.
2.	Siliceous conglomerate of Eocene limestone ...	1·0 „
3.	Consolidated sand, mottled purple and white ...	1·2 „
4.	Conglomerate similar to bed 2	1·0 „
5.	Brownish clay...	13·0 „
6.	Sandy beds	4·0 „
	TOTAL	21·8 metres.

The same beds are found on the base of Shabrawet, but they are of greater thickness.

In the beds in the above section there was a dip of 2 to 3 degrees towards the cliff.

Gebel Ataqa.—The only other place where beds of this age are found is along the north foot of Gebel Ataqa where they overlie Miocene beds to the west, and Eocene beds further east. All along the foot of the cliff there occurs a low plateau of limestone boulders and sand (where not removed by the drainage) which shows a thickness of 10 to 12 metres in the deeper watercourses. This ends at the old quarry opened by the Suez Canal Company.

Along the seashore between Ataqa and Suez, there is a recent, impure, sandy limestone which is quarried for building purposes. This contains shells which are found on the beach at the present day, above it being a loose sand containing *Tridacna* and all the other shells seen on the beach.

If it be desired, this plain deposit of marine origin may be regarded as a Raised Beach of Newer Pleistocene age, while the other deposits previously described may be classed as Older Pleistocene, the two probably representing the Older and Newer Reefs and Beaches of the district to the south of Gebel Zet.

CHAPTER III.

MIOCENE.

THE first place where beds of this age were met with in the survey of this district was at Gebel Dhaher, on which stands the signal tower between Houses Nos. 2 and 4 on the Old Post Road between Cairo and Suez. Here the following section was seen, but the thicknesses of the beds were not very exactly obtained on account of scree covering them:—

Top.	Hard, black, gritty rock	about	2 metres.
2.	Ferruginous calcareous sandstone		11 „

All these rocks were false-bedded and overlaid a basalt flow, which was much decomposed. The beds dipped towards the north at an angle of 5°.

In a wadi passing to the south of House No. 2 and about 4 kilometres eastward, the same beds were again met with, having a slight northerly dip. These also overlaid basalt. About 2 kilometres to the west of this place was a small outlier on the basalt, in which the following section of the beds under the black gritty rock was measured:—

Top.	False-bedded sandstone...	3	metres.
2.	Rounded flint conglomerate...	0·3	„
3.	Calcareous sandy grit	0·75	„
4.	Lenticles of brittle limestone dying out rapidly.	1	„
5.	Marly sandy clay containing grit	4	„
	TOTAL	9·05	metres.

Pieces of fossils were seen in the low mounds to the north, on the south side of the wadi.

About 3 kilometres N.E. of the place previously mentioned on the side of the wadi, a gritty rock with calcareous cement consisting of sub-angular grains of quartzite with pieces of *Pecten* was met with. Below this came a yellowish, sandy grit about 13 metres thick. The dip was about 2° to the north. To the north of this is a ridge of gritty limestone 13 metres thick. Further north, there occurs a ridge of limestone containing a few grits, and casts of small gasteropods and pelecypoda like *Lucina*, pieces of an echinid like *Echinolampas*, while a cast of *Tellina* sp., was found on the scree. This bed was 10·4 metres thick. On the north side of the ridge, external casts of *Lucina ornata*, Ag., and *Cytherea* sp., were found; while many other fossils in a very brittle state were seen in the limestone. North of this ridge is another of yellow, sandy, calcareous, gritty beds 5 metres thick. Beyond this comes a ridge of purplish, hard, gritty limestone let down by a fault against the basalt which forms the base of Gebel Dhaher. This bed is 5 to 6 metres thick. The general dip is 3° N.

About 1 kilometre to the south, casts of *Cytherea* sp., and *Tellina* sp., were obtained from a calcareous sandy grit which lies about 25 metres below that in which *Lucina ornata* was found. Collecting the various data already obtained, the following succession of Miocene beds is made out:—(1)

	Top.	Purplish, hard gritty limestone	5	metres.
	2.	Yellow, gritty beds	5	"
	3.	Porous limestone with few grits containing pieces of *Pecten* sp.; *Echinolampas* sp.; casts of *Cytherea pedemontana*, Bm., and *Lucina ornata*, Ag.	10·4	"
	4.	Gritty limestone	13·0	"
Lower Miocene	5.	Hard, dark, calcareous sand and grit containing:— *Pecten Kochi*, Loc.; *Lucina ornata*, Ag.; *Cardium Michellotii*, Desh.; *C. multicostatum*, Brocc.; *Venus islandicoides*, Lam.; *Venus* sp.; *Tapes vetula*, Bast.; *Tellina planata*, Lam.: *Mactra corallina*, L.; *Corbula revoluta*, Bast.; *Turritella* (*Archimidiella*) *miotaurina*, Sacco.; *Turritella* sp.	2·0	"
	6.	Yellow calcareous sand and grit containing:— *Ostrea* sp.; *Pectunculus* sp.; *Chama* sp.; *Cardita* (*Actinobolus*) cf. *pinnula*, Bast.; *Cardita* sp.; *Lucina columbella*, Lam.; *Lucina* (*Dentilucina*) sp.; *Lucina* sp. (*many*); *Cardium paucicostatum*, Sow.; *C.* cf. *paucicostatum*, Sow.; *C. multicostatum*, Brocc.; *Cardium* sp. nov.; *Cardium* sp.; *Venus multilamellata*, Lam.; *Cytherea* (*Callista*) *pedemontana*, Brn.; *C. erycina*, L.; *Tapes Basteroti*, May.; *T. vetula*, Bast.; *Tellina lacunosa*, Chemn.; *Tellina planata*, Lam.; *T. nitida*, Pol.;		

(1) See Section IV for relations of these beds to older formations.

Lower Miocene		*Tellina* sp.; *Mactra corallina*, Lam.; (=*M. stultorum*, Lam.); *Corbula revoluta*, Brocc.; *Calyptraea chinensis*, Lam.; *Turritella miotaurina*, Sacco.; *T. terebralis*, Lam.; *Ficula condita*, Brongn.; *Oliva* sp.; *Scaphander* sp.	11·0	„
	7.	Calcareous grits with limestone at the base with *Tellina* sp. and *Cytherea* sp....	7·0	„
	8.	Grits and siliceous limestone with *Tapes* sp., *Cardium* sp., *Lucina* sp....	6·0	„
	9.	Yellow siliceous grit containing small *Cardia* ...	5·0	„
	10.	Hard, black calcareous sandstone	1·8	„
	11.	Yellow sandstone and grits...	13·0	„
		TOTAL	79·2	metres.

Basalt underlaid the lowest bed.

As far as has been seen, the Miocene is lying in a basin broken on the north side by a fault which has thrown down the beds 79 metres. The beds have a general dip of 3° to 5° N.E.; but there is also a gentle inclination of about 2° to the N.W. The general characters of these beds are those of shallow-water deposits, evidence of deeper-water conditions being furnished as the higher beds are examined.

About 4 kilometres S.S.E. of Tower No. 3, Gebel Dhaher, the yellow grits (Bed No. 9 of above section) were found to immediately overlie the basalt, beds Nos. 10 and 11 being absent. Further north the following fossils were obtained from Bed 7 of above section:— *Ostrea* sp.; *Cardita* sp.; *Lucina columbella*, Lam.; *L.* sp.; *Cardium* sp.; *Tapes vetula*, Bast.; *Tapes* sp.; *Mactra* sp.; *Corbula Basteroti*, Hörn.; *Corbula* sp.; *Cancellaria* sp.—Here the beds had a dip of 2° to the S.W. There is evidently a low anticline with its axis lying N.W.–S.E. which accounts for the different directions of dip. This is probably the edge of the basin mentioned above.

On the north, the fault noted at Gebel Dhaher was seen to die out about 3·5 kilometres E.S.E. of Tower No. 3. The basalt rapidly disappears on the up-throw side, and the Miocene dips at 10° towards the fault. In a hill on the up-throw side of the fault there were 12 to 13 metres of a greenish calcareous sandy rock, while at its base was a bed containing *Lithothamnium*, *Lucina ornata*, Ag.; *Lucina columbella*, Lam.; *Cardium* sp.; *Corbula revoluta*, Brocc.

A curious circumstance is the orientation of the ridges before and after the fault died out. Before it disappeared the general trend was N.W.–S.E., but as the fault died away the ridges swung round towards the north-east and finally to the south-west.

Further east, going towards Gebel Ansuri, the Miocene was found lying horizontal, while nearer this hill it was dipping to the north-west. The flattening or loss of dip is caused by the dying-out of the fault which necessitates a stretching of the outcrop or a swing round to the north.

Between Houses Nos. 3 and 4 Suez Road.

Near the base of the series further to the east, a calcareous grit was seen, which contained many fossils not well preserved and was dipping north-west. The following fossils have been determined from this bed:—*Pinna* sp.; *Ostrea* sp.; *Pectunculus* sp.; *Cardita* sp.; *Lucina columbella*, Lam.; *Lucina* sp.; *Cardium* sp.; *Cytherea erycina*, Lam.; *Tellina lacunosa*, Chemn.; *Calyptraea chinensis*, Lam.; *Turritella terebralis*, Lam.; *Turritella* sp.

Nearer House 4 on the Old Post Road to Suez, the remains of a plug of coarse conglomerate firmly cemented by ferruginous material was seen. This is the filling-up of the throat of a geyser or thermal spring. It has undergone denudation prior to being covered by the beds, and there is not the least sign of any alteration of the beds round it; it must therefore have been in existence before the Miocene sea invaded this region. This is important as Blanckenhorn, (1) on the authority of Sickenberger and Schweinfurth, claims to find true siliceous sinter or jasper in the Miocene. This can only be accepted as indicating the occurrence and not the age of this mineral. Behind House No. 4, Miocene beds are again seen, consisting at the top of a brown ferruginous almost crystalline but unfossiliferous limestone. Beneath this, comes an impure calcareous grit which contained numerous specimens of *Pecten* sp.; *Ostrea* sp.; *Modiola* sp.; *Lucina columbella*, Lam.; *L. ornata*, Ag.; *Lucina* sp. nov.; *Lucina* sp.; *Cardium* sp. (many); *Venus* cf. *islandicoides*, L.; *Venus ovata*, Penn.; *Venus* sp. ? *Cytherea* sp.; *Tapes* sp.; *Tellina nitida*, Pol.; *Tellina planata*, L.; *Turritella terebralis*, Lam.; *Strombus* sp.; (?) *Panopaea* sp. This bed was about 4 metres thick.

Between Gebel Ansuri and El Angobia.

On the north side of the dome which lies between Gebel Ansuri and El Angobia, Miocene beds are let down by an east and west fault against the Oligocene, having a tilt of 10° towards the fault. Farther on, the Oligocene is nipped out and the Miocene is laid against the Eocene. The indications here point to the Miocene forming a dome, as the dip seems to radiate from a centre, but the main dip is about 8° westward. This gradually lessens as the escarpment bends round

(1) "Das Oligocän." Neues 4 z. Geol. u. Palaont. Aegyptens. Zeitsch. d. Deutsch. geol. Gesells., 1900, p. 478.

to the south. Here the beds are different in character to those previously seen; this may be due to a deepening of the sea in which they were deposited. The following beds were seen in a cliff:—

Top. White porous limestone, unfossiliferous.
2. Yellowish limestone.
3. Thin bed of current-bedded grit.
4. Yellowish limestone with fossils.

The cliff was about 25 metres high.

Further along the fault line to the east, basalt outcrops from under the Miocene beds and rests on the fault against the Eocene. A little beyond this is a well-preserved example of a geyser pipe rising through the Eocene. Against this the following section of the Miocene beds was obtained:—

Top.	Yellow, sandy limestone	11·5	metres.
2.	Grits	5·0	„
3.	Calcareous sandstone	14·0	„
4.	Yellow calcareous grit containing, *Pectunculus* sp.; *Venus scalaris; Turritella cathedralis* Brongn.; *T. terebralis*, Lam.; *Solarium Carocollatum*, Lam.	9·0	„
5.	Yellow calcareous grit with *Clypeaster*	8·0	„
6.	Grits containing pockets of marl, passing into marls, and again into calcareous grits, containing *Avicula hirundo* var. *phalaeanacea*, Lam.; *Modiola* sp.; *Lucina ornata*, Ag.; *Cardium multicostatum*, Brocc.; *Cardium* sp.; *Dosinia Adansoni*, Phil.; *Venus (Amiantis) gigas*, Lam.; *Tapes vetula*, Bast.; *Tapes* cf. *vetula*, Bast.; *Tapes* sp.; *Turritella terebralis*, Lam.; *T. cathedralis*, Brongn.; *Conus* sp.; *Pleurotoma (Drillia) trochlearis*, Hörn.	12·0	„
7.	Flint conglomerate containing pieces of *Pecten*.	5·0	„
	TOTAL	64·5	metres.

Underneath these beds came the basalt. Beds 5 to 7 were not in the direct section but were found further to the north where they outcropped. Their dip was 4° to the south.

Leaving this area for the time being, a traverse was made between El Angobia and Bir Gendali in order to determine the boundary between the Miocene and Oligocene. It was found impossible to do so as the junction was masked by down-wash. The country was occupied by a series of ridges of grit and conglomerate of which Gebel Ali Hamum el Aberaq formed the highest point, and at the base basalt was seen in the wadis. This showed that this series of beds was to be regarded as of Miocene age, and this was found to be supported later on by finding these conglomerates further north containing Miocene fossils. These conglomerates cover a wide area.

Gebel Rieshi. About 12 kilometres north-east of Bir Gendali a cliff was reached which on examination proved to be Miocene. A section was measured, although the main cliff was not in a good condition for doing so.

Top.	Gritty limestone and sandstone, containing *Lithothamnium*, etc.	36·0	metres.
2.	False-bedded white sandstone	1·0	„
3.	Yellow ferruginous grit containing numerous pebbles, pieces of *Clypeastridae*, casts of *Cytherea*, etc....	1·2	„
4.	Marly beds	5·8	„
5.	Coarse ferruginous grit	2·0	„
6.	Yellow sandy beds	2·5	„
	TOTAL	48·5	metres.

There is a dip of 3° S., and the cliff is faulted against the Oligocene by a N.W.–S.E. fracture. The base of this formation was not seen, but the plain was formed of conglomerate beds.

Further east, a better exposure of the cliff itself was seen which gave the following thicknesses :—

Top.	Calcareous grits	10·0	metres.
2.	Lithothamnium limestone	1·0	„
3.	Calcareous grits	9·0	„
4.	White false-bedded sandstone	2·5	„
5.	Marly sandstone	5·5	„
6.	Calcareous sandstone with flint pebbles	7·5	„
	TOTAL	35·5	metres.

On the top of the cliff going towards the fault, some higher beds were found containing *Ostrea Virleti*, Desh.; *O. digitalina*, Eichw. var. *Rohlfsi*, Fuchs. Below this came a bed containing *Anomia ephippium* var. *pergibbosa*, Sacc.

Further north various other fossils were collected, such as *Pecten cristatocostatus*, Sacco. ; *P. Geneffensis*, Fuchs. ; and some casts, from the foot of a hill 18 kilometres N.E. of Bir Gendali. Above these were found *Ostrea Virleti*, Desh., and *O. digitalina*, Eichw. var. *Rohlfsi*, Fuchs. These fossils come from a brownish to whitish limestone and a calcareous sandstone, the latter containing many Clypeastridæ, which are much broken and cannot be got out of the rock as it is so hard.

The beds in this area are lying more or less in the form of a flat dome, as the dips radiate from a centre. The dips are to S.E. 5°, to E. 2°, to W. 3°, and N.E. and N. about 3°.

The beds also lie in low folds with their axes in a north and south direction; but these are subsidiary to the dome.

Going west from the cliff of Rieshi, a continuation of the Miocene beds was found capped by a layer of sand and gravel about 5 metres thick which is probably Pleistocene in age. To the south, it apparently thickens and completely masks the Miocene. Further west the same beds were seen, their dip being to the east. This allows of their overtopping the grits and conglomerates to the west, and shows that these should be regarded as the lowest members of the Miocene.

Collecting the various data which were observed in this area, the following is a generalised section of the Miocene:—

Top.	Reddish, gritty limestone	4·0	metres.
2.	Yellow, gritty bed with *O. Virleti*, Desh.; and *O. digitalina*, Eichw. var. *Rohlfsi*, Fuchs. ...	1·0	„
3.	Calcareous grits with *Anomia ephippium*, var. *pergibbosa*, Sacc.	10.0	„
4.	Lithothamnium limestone	1·0	„
5.	Calcareous grits	9·0	„
6.	Whitish, false-bedded sandstone...	2·5	„
7.	Marly sandstone containing *Pecten cristatocostatus*, Sacco.; *P. submalvinae*, Blanck.; *Cardita* sp.; *Cardium multicostatum*, Brocc.; *Cardium* sp.; *Venus multilamellata*, Lam.; *V. scalaris*, Bronn.; *V.* cf. *islandicoides*, Lam.; *Cytherea erycina*, Lam.; *Tapes vetula*, Bast.; *Tellina lacunosa*, Chemn.; *Turritella terebralis*, L.; *T. cathedralis*, Brongn.	5·5	„
8.	Calcareous sandstone with flint pebbles in it ...	7·5	„
9.	False-bedded sandstone	2·0	„
10.	Conglomerate and grit containing Clypeastridae, *Pecten Geneffensis*, Fuchs.; *P. cristatocostatus*, Sacc.; *P. cristatus*, Bronn.; *Pectunculus* sp.; *Cardita* sp.; *Cardium* sp.; *Venus (Amiantis) gigas*, Lam.; *V. multilamellata*, Lam.; *Venus* sp.; *Cytherea erycina*, Lam.; *Cytherea* cf. *pedemontana*, Ag.	0·8	„
11.	Marly grit	6·4	„

Lower Miocene	12.	Hard gritty band containing *Pecten* sp.; *Ostrea* sp.; *Pectunculus* sp.; *Chama* sp.; *Lucina ornata*, Ag.; *L. columbella*, Lam.; *Lucina* sp.; *Cardium multicostatum*, Brocc.; *Cardium* sp.; *Dosinia Adansoni*, Phil.; *Venus* sp.; *Cytherea* sp.; *Tapes vetula*, Bast.; *Tellina lacunosa*, Chemn.; *T. nitida*, Pol.; *Tellina* sp.; *Clavagella* sp.; *Natica* cf. *millepunctata* Lam.; *Turritella terebralis*, Lam.	0·75 metres
	13.	Marly grit	3·0 „
	14.	Hard ferruginous grit containing *Pectunculus* sp.; *Cardita* sp.; *Cardium multicostatum*, Brocc.; *Cardium* sp.; (?) *Venus* sp.; *Cytherea* sp.; *Tapes vetula*, Bast.; *Tellina lacunosa*, Chemn.; *Mactra* sp.	1·25 „
	15.	Sandy marl	5·6 „
	16.	Calcareous sandy beds	4·3 „
		(Basal beds not seen clearly enough to continue the section).	
		TOTAL	64·6 metres.

Near the continuation of the ridge or dome of El Angobia, the Miocene beds were seen to bend rapidly round with a dip of 4° to the north-east. There is probably a fault near here, as the Miocene lies against the Oligocene.

North of El Angobia.

North of El Angobia the Miocene is seen overlying a thick flow of basalt (17 to 18 metres). Next the basalt comes the conglomerate bed followed by the grits in due course. There is an undoubted unconformability between the basalt and the Miocene. Here it would seem as though the basalt has undergone considerable denudation before the Miocene was deposited, as it stands upon rounded knolls or hummocks like islands in the Miocene beds. As if in support of this idea, numerous denuded geyser stumps or plugged fissures are likewise seen rising out of the Miocene. These have undoubtedly been there before the Miocene sea covered them.

About 2 kilometres north of where the basalt is last seen, and a little to the north of the Post Road to Suez, midway between Houses 5 and 6, there is a low cliff of Miocene beds. Here the bed corresponding to No. 12 of the above section was seen, from which numerous fossils were collected. The dip here is 5° to the north-west. In the bed underlying were a few fragments of fossil wood, which have apparently been derived from the Oligocene, as they could not be *in situ* in a marine deposit. The beds at this place are cut up into ridges which run more or less parallel with each other, and at first sight it seems as if this were their natural sequence, but examination shows them to be the same with valleys cut through them. Further to the north the Miocene is let down by a fault against the Oligocene of the wide valley, up which the Old Suez Railway ran.

Passing along the Old Post Road past Houses 6 and 7 towards Der el Beda, the plain in which this road lies is seen to be composed of the conglomerate beds which lie at the base of the Miocene. Here a fault has let them down against the Oligocene. It runs parallel with the road until House 7 is reached, when it bends off to the north-east, returning to the neighbourhood of the road near Der el Beda. Crossing the Oligocene ridge, it was found that the Miocene has been faulted down on its north side also, the fault meeting the southern line of fracture at a point 2·5 kilometres west of House 6.

About 3·5 kilometres north of this house is a small series of ridges of Miocene limestones, marls and conglomerates. From one of the beds was collected numerous specimens of *Tellina lacunosa*, Chemn.; *Tellina* sp.; *Pecten* sp.; several *Lucina ornata*, Ag.; and *Turritella* sp. This may be called the "Tellina" bed, from the numbers of that fossil present in it; it corresponds to Bed 12 of the section given on pp. 35-6. Numerous other fossils were collected from the beds below this.

The same beds as those noted at Gebel Rieshi are present, except that none of the rocks above Bed 5 of the section have been found here. It is to be noted that the colour of the beds varies from that seen in Gebel Rieshi. At this place the gritty bed so full of *Clypeastridæ*, *pectens*, etc., has yielded nothing. The sandy strip between the cliff and the Oligocene is occupied by the lower members of the series. To the north, the fault mentioned as throwing down the Miocene against the Oligocene in the wide valley still persists, and a kilometre to the east is cut off by a dip-fault which throws forward the Miocene beds for 0·5 kilometres to the north-east.

On the east side of the dip-fault, in the angle formed by it with the strike-fault, the following fossils were collected from a yellow limestone at the top of the cliff, which is apparently higher in the series than any previously met with:—*Ostrea Virleti*, Desh.; *O. digitalina*, Eichw. var. *Rohlfsi*, Fuchs; and *Echinolampas amplus*, Fuchs. A little further on, the following higher beds were found:—

Top.	White limestone with *pectens*, *Clypeastridae* and plates of *Cidaridae*	4·0	metres.
2.	Yellow, ferruginous limestone	1·0	„
3.	Hard limestone weathering purple	4·8	„
4.	Hard white limestone...	2·4	„
5.	Marl	0·75	„

A little further to the east the following fossils in addition to those already mentioned were obtained from the limestone which comes below the marly bed:—*Pecten Schweinfurthi*, Blanck.; *P. cristatocostatus*, Sacco.; *P. Josslingi*, Sow.; *P. Ziziniæ*, Blanck.; *P. submalvinæ*, Blanck.; *P. Burdigalensis*, Lam.; *Ostrea Virleti*, Desh.; *O. digitalina*, Eichw. var. *Rohlfsi*, Fuchs; *Echinolampas amplus*; and *Lithothamnium* sp.

Further east the beds were seen to be dipping at an angle of 10° towards the north in the vicinity of the fault.

Eastward from the last place where the beds were examined, an exposure of some interest was seen at the Mid-Station on the Old Cairo-Suez Railway. A little to the south-east is a hill of white limestone which has furnished the stone for the buildings there. The beds here are dipping 18° to 20° north, and are let down by a fault against the Lower Miocene beds and Oligocene sands. In the quarry a good collection of fossils was obtained from the loose blocks scattered about. They are the following: *Echinolampas amplus*, Fuchs.; *E. Orlebari*; Gauth.; *Pecten sub-malvinæ*, Blanck.; *P. cristatocostatus*, Sacco.; *Ostrea Virleti*, Desh.; *O. digitalina*, Eichw. var. *Rohlfsi*, Fuchs.; *Ostrea* sp.; *Modiola Escheri*, May.; *Cardium multicostatum*, Brocc.; *Turritella* sp.; *Strombus* sp.; *Cassis* sp.

Close to the Old Railway Station an interesting series of beds was found in a cutting made for some unknown purpose. The beds are quite different in character to any previously examined in this district. The following is the section seen in the sides of the cutting where a dip of 10° N.E. was seen:—

Top.	Gypseous marl	1·5	metres.
2.	Hard, brown, ferruginous, impure limestone, containing many fossils	0·25	"
3.	Gypseous marl	1·0	"
4.	Hard, brown, ferruginous limestone	0·4	"
5.	Gypseous marl	1·0	"
6.	Hard, yellow limestone showing above the bottom of the cutting	1·0	"
	TOTAL	5·15	metres.

From beds 2 and 4, the following fossils were collected, showing these beds to be of Lower Miocene age:—*Pecten* sp.; *Cardita* sp.; *Arca* cf. *Fichteli*, Desh.; *Cardium multicostatum*, Brocc.; *Cardium* sp.; *Dosinia Adansoni*, Phil.; *Venus ovata*, Penn. (many); *V. multilamellata*, Lam.; *V.* cf. *plicata*, Gmel.; *Venus* sp.; *Cytherea erycina*, Lam.; (?) *Clavagella* sp.; *Solarium* sp.; *Trochus* (*Cautrainea*) *tauro-miocænicus*, Sacco.; *T.* cf. *tauro-miocænicus*; *Turbo* (*Cautrainea*) *tauro-miocænicus*, Sacco.; *Turritella terebralis*, Lam.; *Ficula* sp.; *Triton* sp.; *Scaphander lignarius*, Lam.; *Scaphander* sp.

Collecting all the information obtained from the various exposures already examined (except that near Gebel Dhaher) the following is a general section of the Miocene of this district:— **General Section.**

Top.	Hard white limestone containing *Echinolampas amplus*, Fuchs.; *E.* cf. *Orlebari*, Gauth.; Pieces of *Cidaris* sp.; *Clypeaster* sp.; *Pecten Josslingi*, Sow.; *Pecten cristatocostatus*, Sacc.; *P. Schweinfurthi*, Blanck.; *P. Ziziniae*, Blanck.; *P. sub-malvinae*, Blanck.; *P. Burdigalensis*, Lam.; *Ostrea* sp.; *O. Virleti*, Desh.; *O. digitalina*, Eichw. var. *Rohlfsi*, Fuchs.; *Modiola Escheri*, May.; *Cardium multicostatum*, Brocc.; *Turritella* sp.; *Cassis* sp.	4·0	metres.
2.	Yellow ferruginous limestone	1·0	"
3.	Hard limestone weathering purple	4·8	"
4.	Hard white limestone	2·4	"
5.	Marl	0·75	"
6.	Hard yellow limestone with *Lithothamnium* sp.; *Psammechinus dubius*, Ag.; *Echinolampas* cf. *amplus*, Fuchs.; *Pecten* sp.; *Ostrea Virleti*, Desh.; *O. digitalina*, Eichw. var. *Rohlfsi*, Fuchs.	1·0	"
7.	Calcareous grits passing into limestone to the north containing *Lithothamnium*	10·0	"
8.	Lithothamnium limestone	1·0	"
9.	Calcareous sandstone showing current-bedding in a remarkable way	9·0	"
10.	White, false-bedded sandstone, becoming limestone in places	2·5	"
11.	Marly sandstone containing *Pecten cristatocostatus*, Sacco.; *P. sub-malvinae*, Blanck.; *Cardita* sp.; *Cardium multicostatum*, Brocc.; *Cardium* sp.; *Venus multilamellata*, Lam.; *V. scalaris*, Bronn.; *V.* cf. *islandicoides*, L.; *Cytherea erycina*, Lam.; *Tapes vetula*, Bast.; *Tellina lacunosa*, Chemn.; *Turritella terebralis*, L.; *T. cathedralis*, Brongn	5·5	"
12.	Calcareous sandstone with flint pebbles in it; becomes limestone to the north	7·5	"
13.	False-bedded sandstone	2·0	"

	14.	Conglomerate and grit (becomes a sandy, calcareous bed further north) containing *Pecten cristatocostatus*, Sacco.; *P. cristatus*, Bronn.; *Pectunculus* sp.; *Cardium* sp.; *Venus gigas*, Lam.; *V. multilamellata*, Lam.; *Venus* sp.; *Cytherea erycina*, Lam.; *C.* cf. *pedemontana*, Ag.	0·8	metres
	15.	Marly grit	6·4	„
Lower Miocene.	16.	Hard gritty bed (Tellina bed) containing:— *Pecten* sp.; *Ostrea* sp.; *Pectunculus* sp.; *Chama* sp.; *Lucina ornata*, Ag.; *Lucina columbella*, Lam.; *Lucina* sp.; *Cardium multicostatum*, Brocc.; *Cardium* sp.; *Dosinia Adansoni*, Phil.; *Venus* sp.; *Cytherea* sp.; *Tapes vetula*, Bast.; *Tellina lacunosa*, Chemn.; *T. nitida*, Pol.; *Tellina* sp.; *Clavagella* sp.; *Natica* cf. *millepunctata*, Lam.; *Turritella terebralis*, Lam.	0·75	„
	17.	Marly grits	3·0	„
	18.	Hard, ferruginous grit containing:— *Pectunculus* sp.; *Cardita* sp.; *Cardium multicostatum*, Brocc.; *Cardium* sp.; *Venus* sp.; *Cytherea* sp.; *Tapes vetula*, Bast.; *Tellina lacunosa*, Chemn.; *Mactra* sp.	1·25	„
	19.	Sandy marl with *Pectunculus* sp.; *Cardita* sp.; *Tapes vetula*, Bast.; *Tellina lacunosa*, Chemn.	5·6	„
	20.	Calcareous sandy beds	4·3	„
	21.	Gypseous marl	1·5	„
	22.	Hard, brown, ferruginous, impure limestone full of fossils	0·25	„
	23.	Gypseous marl	1·0	„
	24.	Hard, brown, ferruginous limestone	0·4	„
	25.	Gypseous marl	1·0	„
	26.	Hard yellow limestone	1·0	„
		Total	78·7	metres.

Near Gebel Um Qamr.

Crossing the wide shallow valley to the north in which some fairly large sand-dunes have accumulated, the next piece of Miocene was found as an outlier faulted against the Oligocene. As far as could be seen in the absence of good exposures, the whole of the series, with the exception of those below No. 20 in the above section, is represented. The sand-scour here is tremendous in its power, grooving and planing off even the hardest rocks in a most wonderful manner.

Gebel Um Qamr is an outlier which has been tilted by a fault. To the north-west there are some fine examples of wind and sand action. (1) In appearance there are a series of parallel ridges with an apparent dip to the north, the most northerly showing what appears to be a perfect dip-slope. Examination of the beds in detail shows that they are lying practically horizontal, and the parallel ridges are nothing except isolated pieces of a plateau which are being gradually eaten away by the sand-drift from the south-west, acting along certain planes of weakness. A hard bed on top has somewhat retarded the action.

Gebel Gafra. This is a hill composed of Oligocene and Eocene beds with Miocene forming a fringe along the sides, or lying at the foot of the escarpment. On its west end, the Miocene has been faulted down against the Oligocene of the plain by two faults forming a "V" on its western end. The dips vary from N.W., W., to S.W., according as the faults go.

Along the north side of this hill, the Miocene has been let down against the Oligocene by a fault hading north. On the side of this fault is a plug of a small geyser neck or thermal spring; this is on the up-throw side. The Miocene beds here have been thrown into small folds of which only the troughs are left.

On the south side there occurs a small hill of Miocene beds which has been shifted by two dip-faults into the Oligocene, and much twisted and tilted. It has also been let down to the south by the fault which bounds Gebel Gafra on the south. Many fossils were found in the gritty beds, but in bad preservation.

Further east is a small hill of sandstone and marls which has been let down against the Upper Moqattam beds, the throw as estimated from the thickness of the beds displaced is 102 metres. The following fossils were obtained from this place:—*Pecten submalvinæ*, Bl.; *P. cristatocostatus*, Sacco.; *P. Ziziniæ*, Blanck.; *P. Schweinfurthi*, Blanck.; *P. Geneffensis*, Fuchs.; *P.* sp.; *Ostrea digitalina*, Eichw. var. *Rohlfsi*, Fuchs.; *Cardium multicostatum*, Brocc.; *Teredo* sp.

The whole of the plain is now covered with Miocene deposits, but their boundary is not easily determined, as it is masked by a great quantity of gravel and downwash.

In the cutting of the Old Railway to Suez, 4·5 kilometres north of Der el Beda, the lower beds of the series were found on the upthrow side of the fault which bounds the plain on the south. From these

(1) Section VI.

the following were collected :— *Pecten Kochi*, Loc.; *P. cristatocostatus*, Sacco.; *Cardita* (*Actinobolus*) *pinnula*, Bast.; *Lucina columbella*, Lam.; *L. ornata*, Ag.; *Tellina lacunosa*, Chemn.; *Turritella cathedralis*, Bronn. This bed probably corresponds to No. 16 of the above section.

At this place the Miocene has been carried forward to the north by a dip-fault for about 3 kilometres.

It is seen on examination that the beds in the plain are the lowest in the series, and are lying horizontal, the higher beds occupying the sides. It thus seems that the plain is the result of denudation.

To the south of the fault, between it and Der el Beda, the white limestone of the Miocene appears, followed by the marly, sandy beds to the south, the latter resting unconformably on the Oligocene against which it is let down by a fault hading to the north. Here the following fossils were obtained from the horizon of Bed 14 of the foregoing sections : — *Orbicella microcalyx*, Greg. ; (Felix sp.). ; *O. Humphreysi*, Felix; *Porites incrustans*, Defr.; *Pecten cristatus*, Bronn.; *P. cristatocostatus*, Sacco.; *P. submalvinæ*, Blanck.; *P. Schweinfurthi*, Blanc.; *P. Ziziniæ*, Blanck.; *P. Zitteli*, Fuchs.; *Spondylus crassicostata*, Lam.; *Ostrea digitalina*, Eichw. var. *Rohlfsi*, Fuchs.; *Ostrea Virleti*, Desh.; *Ostrea* sp.; *Cardita crassicosta*, Lam.; *Cardita* sp.; *Venus* cf. *Aglauræ*, Hörn. ; *V. islandicoides*, Lam. ; *Cytherea erycina*, Lam. ; *Gastrochæna* sp.

From the horizon of Bed 6 there were obtained :—*Echinolampas amplus*, Fuchs.; *Pecten sub-malvinæ*, Blanck.; *P. Ziziniæ*, Blanck.; *Cardium* sp.; *Venus* cf. *Aglauræ*, Hörn.

Wadi Gafra. At the point where the Wadi Gafra collects all the drainage of the country to the south into one watercourse, a dip-fault has carried the escarpment of the Miocene forward a distance of two kilometres. Here the water has breached the escarpment along the line of fracture by a narrow gorge or "Moqta." On the upthrow side of the fault, a section was measured, which, although the place was not an ideal one, gave some clue to the possible position of the lower beds given in the previous section. The following is the detailed measurement :—

Top.	Hard white limestone...	1·0	metres.
2.	White limestone with *Lithothamnium* sp.; *Clypeaster* sp.; *Echinolampas* sp.; and *Pecten* sp.	7·3	„
3.	do. but containing more fossils	6·0	„
4.	White, sandy limestone with few fossils ...	4·0	„
5.	White limestone with *Clypeaster* sp.; *Pecten* sp.; and *Ostrea* sp.	1·0	„
6.	Sandy marls	6·0	„

7.	False-bedded sandstone	6·0	metres
8.	Sandy marl	1·0	„
9.	Grits and false-bedded sandstone	4·2	„
10.	Sandstone with pebbles	5·0	„
11.	Greenish yellow marls	6·0	„
12.	Sandy yellow beds	3·0	„
13.	Marly beds like No. 11.	1·75	„
14.	Hard brown sandy limestone containing fossils	1·50	„
15.	Marly beds similar to Nos. 11 and 13	1·0	„
16.	Hard brown limestone	1·0	„
	TOTAL	55·75	metres.

After comparison with the thicknesses in the previous section it was found that lower beds were not present. The difficulty of getting fossils out of the rock and the presence of much scree made it difficult to correlate the beds correctly.

This cliff extends eastward past the basalt neck up to the western flank of the foot-hills of Gebel Awebed, and preserves its general character in a remarkable way. The fault which let it down on the south side of the plain along which the Old Cairo-Suez Railway lies, dies out to the north of the basalt neck.

To the south of the Oligocene which here forms gravel-topped ridges, Miocene has again been let down along the edge of the plain in which is the Old Post Road to Suez. This plain is in all probability formed of the lower members of the Miocene. From this spot was obtained *Pecten sub-malvinæ*, Blanck.; *P. Blanckenhorni; Ostrea digitalina*, Eichw. *var. Rohlfsi*, Fuchs.; *Ostrea* sp.

From the base of the Miocene 15 kilometres east of Der el Beda the following fossils were obtained :— *Scutella Deflersi*, Gauth.; *Scutella* sp.; *Brissopsis* sp. nov.; *Pecten Kochi*, Loc.; *P. Schweinfurthi*, Blanck.; *Pecten Ziziniæ*, Bl.; *P. Submalvinæ*, Blanck.; *P. Burdigalensis*, Lam.; *Pecten* sp.; *Pectunculus* sp.; *Cardita* sp.; *Cardium paucicostatum*, Sow.; *C. multicostatum*, Brocc.; *Cardium* sp.; *Dosinia orbicularis*, Ag.; *Venus* sp.; (?) *Cytherea* sp.; *Tapes vetula*, Bast.; *Corbula revoluta*, Brocc.; *Turritella* sp.; *Ficula condita*, Bronn. There is here a mingling of Lower and Middle Miocene types which points to the border line between the two stages. If the echinids and pecten fauna be taken into consideration, with the exception of *P. Kochi* they prove the Middle Miocene age of the bed. If on the other hand *Cardium paucicostatum*, *Corbula revoluta*, *Tapes vetula*, and *Ficula condita* be taken, there is here an assemblage of fossils which might be found in any Lower Miocene deposit. It is to be noted, however, that the pectens and echinids occur in the upper part of the bed, while those with a Lower Miocene facies are found in the lower half.

Gebel Gafeisad or Agleiat Qamr.

Round this hill the Miocene forms a sort of semi-circle on the south and west sides. (1) It is faulted against the Oligocene which is raised on the edge of the volcanic neck; while on the north-east side also it is let down by a fault. In the greater part of the cliff, the upper beds of the general section are absent, while the lower are below the level of the plain or covered by down-wash. On the south-west side, however, the lower beds are seen at the base of the cliff about 2 kilometres from Gebel Gafeisad. Here Bed 14 yielded the following fossils:—*Orbicella Guettardi; Clypeaster acclivis*, Pomel.; *Pecten Ziziniæ*, Blanck.; *P. cristocostatus*, Sacco.; *P. Kochi*, Loc.; *Ostrea virleti*, Desh.; while in the sands below pieces of mammalian bones were found, but in a very bad state of preservation.

To the east of Gebel Gafeisad, the Miocene is let down to the east and south against the Oligocene. These faults gradually die out and the Oligocene appears eventually as a ridge in the Miocene, being brought on a fold from which the Miocene has been worn away. There appears here a combination of two sets of folds, as the Oligocene beds disappear under the Miocene beds and outcrop again to the east of El Gherbe, which is the remains of a syncline. In the Miocene there is scarcely any dip at all, and it lies horizontally upon the Oligocene. This would point to the large open plain of El Hammad being made of Oligocene. In this neighbourhood the action of the sand and wind is very marked as shown by the grooving and ridging of the beds. In many places the beds are grooved and polished as if a glacier had passed over them.

Between El Gherbe and Gebel Shabrawet the Miocene has been let down by a fault against the Eocene along the edge of the plain. Here the limestone has been planed down considerably by sand action, and it is doubtful if any real dip exists. In this ridge at Gebel Faied, Blanckenhorn (2) describes a section of 22·5 metres of limestones, marls and clays, containing:—*Lithothamnium; Heterostegina; Cellepora polythele; Avicula* aff. *tarentina; Clypeaster acclivis; Pecten latissimus; P. submalvinae; P. Ziziniae; P. cristatus; P. cristatocostatus; P. Burdigalensis; P. gloriamaris* var. *longævis* Sacc.; *Perna Soldani; Ostrea*

(1) See Section III.
(2) Op. cit. p. 86-87.

Virleti; O. digitalina; Venus cf. *plicata; Cytherea erycina; Tapes* cf. *vetula; Turritella tricarinata; Conus* sp.; *Cassis* sp.; *Natica* sp. In this ridge the author also found the following in descending order 4·5 kilometres W. of Shabrawet:—From bed 8 (of General Section p. 13, MS.) *Cellepora palmata*, with *Cryptangia parasitica* Mich.

From Beds 11 and 12, but mainly 11:—*Clypeaster isthmicus* Fuchs.; *C. pentadactylus* Peron et Gauth.; *Scutella Deflersi*, Gauth.; *Echinolampas* cf. *amplus* Fuchs; *Pericosmus latus* Ag.; *Pecten Schweinfurthi* Blanck.; *Ostrea Virleti* Desh.

Further east the lower sandier beds of the Miocene are nipped out, the Eocene and Miocene limestones being brought together.

Crossing the Eocene and Oligocene beds to the main mass of the Miocene on the upthrow side of the fault, a place was selected for another section to be measured, as the beds seemed to be changing in character. This lies 12·5 kilometres WSW. of Gebel Shabrawet (See Profile No. 1 and Section II).

The following are the details of the section:—

Top.	Hard white limestone containing *Orbicella* cf. *Defrancei; O. microcalyx*, Felix sp.: *Goniastrea halicora*; *Echinolampas amplus*, Fuchs.; *E.* cf. *amplus*, Fuchs.; *Pecten Ziziniae*, Blanck.; *P. submalvinae*, Blanck.; *P. cristatocostatus*, Sacco.; *Perna* sp.; *Ostrea digitalina*, Eichw. var. *Rohlfsi*, Fuchs.; *O. virleti*, Desh.; *Lithodomus*, sp.; *Chama* sp.; *Chama*, cf. *gryphyoides*, Lam.; *Venus gigas*, Lam.; *V.* cf. *islandicoides*, Lam.	3·0	metres.
2.	Soft white limestone with similar fossils ...	4·5	„
3.	Hard white limestone forming a ledge	1·75	„
4.	White lithothamnium limestone	8·5	„
5.	Softer white limestone containing *Echinolampas* cf. *amplus* Fuchs.; *Pecten submalvinae.*; *Lithodomus* sp.; and *Panopaea Ménardi* Desh.	6·0	„
6.	Harder white limestone with a few pectens ...	7·6	„
7.	White limestone containing *Lithothamnium; Corals; Ostrea Virleti; Teredo* sp.	4·4	„
8.	Yellowish limestone with *Cellepora palmata*, and *Cryptangia parasitica*, Mich.; *Ostrea digitalina*, Eichw. var. *Rohlfsi*, Fuchs.; *O. gingensis* var. *setensis* Blanck.; *O. Virleti*; *Teredo* sp.		
9.	Blue marly clay containing:—*Bryozoa; Pecten Josslingi.* Sow.; *P. Kochi*, Loc.; *Mytilus* sp.; *Cytherea erycina*, Lam.; *Siliquaria* sp.; *Strombus* sp.; *Conus* sp.	0·5	„

10. Gritty sandstone...	9·5	metres
11. Falsebedded gritty sandstone	2·5	„
12. Marly beds brownish at base, but blue at top containing gypsum and ferruginous nodules, and *Psammechinus Fuchsi* Gauth.; *Clypeaster* sp.; *Pecten cristatocostatus; P. Josslingi; P.* cf. *Zitteli*, Fuchs.; *P. revolutus*, Mich.; *P. Ziziniae.; P. concavus*, Blanck.; *P. Schweinfurthi.*; and *P. Kochi*	7·3	„
13. Brown limestone with *Cellepora polythele* R. var. *sub-globosa*, Fuchs.; *Psammechinus dubius*, Ag.; *Cidaris avenionensis*, Desh.; *Clypeaster acclivis*, Pomel.; *Scutella* sp.; *Echinolampas* cf. *amplus.; Pericosmus latus*, Ag.; *Bryozoa.; Pecten submalvinae.: P. burdigalensis; P. Kochi; P. Schweinfurthi; P. Geneffensis; Spondylus crassicostatus*, Lam.; *Ostrea Virleti; O. digitalina; Ostrea* sp.: *Mytilus* sp.; *Modiola Escheri*, May.; *Arca* sp.; *Pectunculus* sp.; *Cardita* sp.; *Cardium* sp.; *Venus gigas*, Lam.; *V.*, sp.; *Cytherea erycina; Xenophora* sp.; *Siliquaria anguina* L.; *Natica* sp.; *Turritella terebralis*, L.; *T. cathedralis*, Brongn.; *Ficula condita*, Brongn.; *Scalaria amoena*, Phil.; *Triton* sp.; *Conus* sp.; *Serpula* sp.; *Balanus* sp.	0·5	„
14. Marly limestone containing *Ostrea digitalina* var. *Rohlfsi* and *O. Virleti*	2·0	„
15. Limestone containing *Lithothamnium* sp.; *Cidaris avenionensis*, Desm.; *Clypeaster isthmicus*, Fuchs.; *Scutella Deflersi*, Gauth.; *Echinolampas amplus*, Fuchs.; *E. Orlebari*, Gauth. and some pectens	5·3	„
16. Grits	2·5	„
17. Grits with *Clypeaster* sp. and *Pecten* sp. ...	1·0	„
18. Hard yellow limestone with grits	1·75	„
TOTAL...	76·5	metres.

Compared with the beds given in the previous sections, there is a considerable modification in the characters of the beds, which points to a deepening of the water towards the east. Taking the Gritty Sandstone with the Falsebedded Sandstone at its base as a landmark (this has been found an excellent indicator), it is found that the limestones above it have thickened considerably and become purer, while the Ostrea, only previously found at the top of the series, are found to exist in them from top to bottom. These fossils likewise make their appearance below the sandstone. Below the sandstone the changes are equally apparent, for whereas in the previous section it was a succession of sandstones and grits, in the present one these are represented by marls and limestones with some gritty beds at the base. The lowest bed in this section corresponds to Bed 20 of the previous section which marks the lowest member of the Helvetian stage. Evidence of the gradual change of the character of the beds was seen in the different places where they were examined subsequent to the measurement of the previous section, and it was on account of this that the present section was measured so as to guard against a false correlation later on.

Between this place and El Gherbe the outcrops of the marly beds of the Miocene and the Oligocene sands vary considerably. This seems to depend on the position of the anticlines and synclines into which the older beds were thrown prior to the deposition of the Miocene. On the east and west sides the beds in the Miocene gradually become lower and lower until they lose themselves in the level of the plain; this is largely due to the planing-down of the limestones by sand-drift, thus forming a false dipslope,(1) while in reality the beds in the plain are the lower members of the series. On the extreme east corner of this cliff (the Fuchsberg of Schweinfurth) a small fault has caused a reduplication of the beds and produced a wider outcrop of the underlying beds. From this point the beds are gradually worn down to plain level near the old Railway Station of Awêbed.

Gebel Genefe.

This place has been examined by many geologists and many differences of opinion have been expressed about the age and position of the beds found there. In 1900, MM. Deperet and Fourtau (2) published a paper in which they claimed that 16 metres of sandstone found there belong to the Burdigalien, while another section of 11 metres of limestones which they regard as superposed on the sandstone represent the Vindobonien or Upper Miocene.

Blanckenhorn (3) regards these sections as being parallel with each other and not superposed, and believes all the beds in this place to be Helvetian or Middle Miocene. He gives three sections which he examined and correlates them with those of the previous authors. This same author (4) speaking of the earth movements which preceded

(1) See Section VI., Sketch I.
(2) Comptes Rendus des Séances de l'Acad. des Sciences, 1900, p. 402.
(3) "Das Miocän" Zeitschr. d. Deutsch. Geol. Gesells., 1901, pp. 85-6.
(4) do. do. " " " " " 1901, p. 68.

the Miocene, says that the Eocene was thrown by faults into a series of "horsts" against which the Miocene was laid in a reef-like manner. Gebel Genefe was one of the examples of "horsts" given. This statement is not correct as regards this area, and a glance at Section I., will show that the only possible explanation of the difference in level of the beds at the two places—Fuchsberg and Genefe—is faulting.

It is to be regretted that in neither case do the authors above mentioned give a definite position to their sections, so that subsequent workers who wish to test the evidence adduced could examine the actual places.

At the foot of the Eocene cliff (1) from 0·5 to 0·75 kilometres to the north of the Genefe Co's Houses the beds correspond generally to the lowest seen in the previous Section (12 km. W.S.W. of Shabrawet). At this place the signs of deepening water are much accentuated; the sandstone with false-bedding has been replaced by a calcareous sandstone which weathers in a spheroidal manner and contains numerous fossils.

At the corner of the cliff on the north end of Gebel Genêfe the Miocene beds have been let down at least 97 metres ; the fault gradually dies out towards the south until it is replaced by a syncline in the Eocene in which the Miocene lies.

At 2·5 kilometres S·E. of Genefe Co's Houses (2) the following section was seen: —

Top.	Calcareous sandy beds...	3·5	metres.
2.	Gritty limestone full of small *Gryphæa mediterranea*	5·4	„
3.	Brown sandy beds with hard calcareous concretions	5·0	„
4.	Gritty limestone containing *Pericosmus latus ; Gryphæa mediterranea ; Ostrea* sp. ; *Lithodomus* sp. ; (?) *Cytherea* sp. ; *Natica* sp.	2·0	„
5.	Brown sandier beds containing casts of pelecypoda	5·0	„
6.	Greyish limestone containing along with the previous bed the following fossils : *Clypeaster acclivis*, Pomel. ; *Pliolampas Pioti*, Gauth. ; *Pecten Burdigalensis ; P. Kochi. ; P. Ziziniæ; P. submalvinæ*, P. (*Macrochlamys*) nov. sp. ; *P. cristatocostatus ;*		

(1) Plate. III.
(2) See Profile II., Plate III, and Section I.

Cliff of Gebel Genefe showing the Miocene faulted down against the Lower Moqattam.

	Pectunculus sp.; *Cardita* sp.; *Lucina* sp.; *Diplodonta rotundata*, Mont.; *Cardium paucicostatum*, Sow.; *Cardium* sp.; *Tapes* sp.; *Tellina* sp.; *Teredo* sp.; *Strombus* sp.; *Cassis* sp.	7·5	metres
7.	Brownish sandy limestone...	0·5	„
8.	Marly greenish clay, streaked purple and red, and containing much gypsum	17·0	„
		45·9	„
	Below this bed further on comes:		
9.	Brown impure sandy limestone	0·75	„
10.	Greenish marly clays to ground level	2.0	„
		48·65	metres.

The following is a section measured about 1 kilometre south of the Genefe Co's Houses:

Top.	Yellowish limestone containing *Lithophyllia* sp.; *Echinolampas Orlebari*; *Lithodomus* sp.; *Cardita crassicosta*, Lam.; *Chama* sp.; *Venus* cf. *gigas.*; *Pholadomya Puschi*, Goldf.	7·0	metres.
2.	Soft, yellowish lithothamnium limestone ...	3·0	„
3.	Harder grey limestone standing out in the cliff and containing *Lithothamnium* and *Ostrea* sp.	3·0	„
4.	Softer white chalky limestone with *Echinolampas* sp.; *Pectens*; *Ostrea Virleti*; and *Gryphaea mediterranea*	11·0	„
5.	*Lithothamnium* limestone with a few *Pectens*	9·0	„
6.	Bed similar to No. 4 containing *Echinolampas*; *Pectens*; and *Gryphaea mediterranea* ...	3·5	„
7.	White limestone with *Lithothamnium*; *Heterostegina* sp.; *Echinolampas* sp.; *Pecten* sp.	2·5	„
8.	*Heterostegina* limestone	3·0	„
9.	*Heterostegina* limestone containing *Cellepora palmata* with *Cryptangia parasitica*; *Clypeaster acclivis*; *Pecten submalvinae*; *P. Kochi*, Loc.; P. (*Macrochlamys*) sp. nov.; *Spondylus crassicostatus*, Lam.; *Ostrea Virleti*; *Cardium* sp.; *Cytherea* sp.; *Turritella terebralis*, Lam.; *T. cathedralis*, Brongn.; *Ficula* sp.	8·0	„
10.	*Heterostegina* limestone containing many pectens of the same species as those above.	1·0	„
11.	Brown clayey bed	1·0	„

	12.	Greenish marly beds streaked with gypsum and containing flat, lenticular, ochreous concretions	18·0	metres.
	13.	Calcareous sandy beds	3·5	„
	14.	Gritty limestone with *Gryphæa mediterranea*	5·4	„
	15.	Brown sandy beds with hard calcareous concretions	5·0	„
	16.	Gritty limestone containing *Pericosmus latus; Ostrea* sp.; *Gryphæa mediterranea; Lithodomus* sp.; (?) *Cytherea* sp.; *Natica* sp.	2·0	„
	17.	Brown sandier beds containing together with Bed. 18....	5·0	„
	18.	Greyish limestone, *Clypeaster acclivis; Pliolampas Pioti,* Gauth.; *Pecten Ziziniæ; P. Burdigalensis; P. submalvinæ; P. Kochi; P. cristatocostatus; P.* (*Macrochlamys*) sp. nov.; *Pectunculus* sp.; *Cardita* sp.; *Lucina* sp.; *Diplodonta rotundata,* Mont.; *Cardium* sp.; *C. paucicostatum,* Sow.; *Tapes* sp.; *Tellina* sp.; *Panopæa intermedia,* Sow.; *Teredo* sp.; *Strombus* sp.; *Cassis* sp. ...	7·5	„
Lower Miocene.	19.	Brownish sandy limestone	0.5	„
Lower Miocene.	20.	Bed of gypsumized limestone	1·0	„
Lower Miocene.	21.	Gypseous clays	3·0	„
Lower Miocene.	22.	Sandier gypseous clays	13·0	„
Lower Miocene.	23.	Brown impure sandy limestone	0·75	„
Lower Miocene.	24.	Greenish marly clays to ground level	2·0	„
		Total...	118·65	metres.

In this section Beds 1 to 20 correspond to those seen in the Section, 12 kilometres WSW. of Shabrawet, although in general the beds are much thickened, and have been deposited in deeper water. The main points of difference here are the replacement of the gritty and falsebedded sandstones of the previous sections by Heterostegina limestone. Up to this point no fossils have ever been found in these beds. Another point to be noticed is the great thickening of the clay bed under the Heterostegina limestone, as well as the beds below it. This all points to better supply of sediment, while the increase of limestone indicates a deeper water.

It is strange that Blanckenhorn who spent some days at Genefe should only find about 30 metres of Miocene beds there, and that having found the Heterostegina limestone he did not see the big mass of white limestone also.

The beds below No. 20 in this section may be regarded as belonging to the upper part of the Lower Miocene. In beds 17 and 18 fossils having a Lower Miocene facies mingle with those characteristic of the Helvetian, and this may probably represent the transition stage between the two parts of the Miocene.

About 0·75 kilometres south of the Genefe Co's Houses the Miocene is broken by a dip-fault, the white limestone being let down against the lowest marls seen there, i.e., with a throw of 64 metres.

It is now possible to give a general table of correlation of the beds in the three sections which were measured.

Section I up to Middle Station. Old Railway to Suez.	Section II, 12.5 kilometres WSW. of Shabrawet.	Section III, 2.5 kilometres SE. of Genefe Co's Houses.
		Bed 1 of others not present
Beds 1 to 5...........=	Bed 1 to 6 but much thickened......=	Beds 1, 2, 3 and 4.
„ 6, 7 and 8.......=	„ 7, 8 and 9........=	„ 5, 6 and 7.
„ 9 and 10—False-bedded sands.=	„ 10 and 11........=	„ 8, 9 and 10.
„ 11..............=	„ 12...............=	„ 11 and 12.
„ 12 to 15.........=	„ 13 to 18..........=	„ 13 to 20.
Lower Miocene Beds 16 to 26......	Not present..........=	„ 21 to 24.

Leaving Gebel Genefe and going in the direction of Gebel Awebed the beds are seen to approximate more in character to those in the Shabrawet section than of that at Gebel Genefe. They are, in fact, midway between the two sections, as the sandstones in the middle begin to yield fossils and show the first tendency to pass into limestones. The whole of the beds are here present that were seen in Section II. On the south side of the Old Railway to Suez the Miocene at this point (7 kilometres N.E. of Gebel Awebed) is let in by a trough-fault, between ridges of Eocene and Oligocene. Further west close to an inlier of Eocene, the beds have been shifted to the north by a dip-fault, the more northerly of the two fractures forming the trough-fault being cut off by it. From this place the following fossils were obtained in descending order:—

Top. *Orbicella Schweinfurthi ; O. microcalyx*, Fel. ; *O. Humphreysi*, Fel. ; and *O. ambigua*.

From Falsebedded Sandstone : *Pecten Geneffensis ; P. cristatocostatus ; Spondylus bifrons ; Ostrea* sp.

From the second bed below the previous bed: *Cellepora polythele* var. *subglobosa*, Fuchs; *Pecten Schweinfurthi; P. Josslingi; P. Kochi; P. submalvinae; P. cristatocostatus; P. Geneffensis; Ostrea digitalina; Tellina* sp.

From the next lower bed, *Pecten Ziziniae; P. Schweinfurthi;* and *P. submalvinae.*

Near the foot of Gebel Awebed, the False-bedded Sandstone assumes the appearance of a limestone and is full of *Cellepora palmata; Pecten submalvinae; P. cristatocostatus; P. Geneffensis; P. Burdigalensis; Cardium* sp.; *C. multicostatum; Venus clathrata; Cytherea erycina; Tapes vetula; Tapes* sp.; and *Ficula condita* Brongn.

On the west end of Gebel Awebed the Miocene is a good deal disturbed. It is let down on both sides of a ridge of Lower Moqattam beds, the Upper Moqattam beds being torn in two by the fault, rather than broken in a clean fracture. For the relations of the beds to each other see Section V. On the south side of the ridge of Lower Moqattam beds the Miocene has been let down about 150 metres. Further east where the fault ends, the Oligocene comes up through the Miocene, but is soon covered up once more. The Miocene beds on the south flank of Gebel Awebed are more nearly akin in character to those of Gebel Genêfe than to those in the west and north, in fact, they have almost become identical with them. These are faulted down against the Eocene of Gebel Awebed. (See Section II for the relations of the rocks to each other.)

The Miocene practically occupies the whole space between the foot of Gebel Awebed and Gebel Ataqa. In the middle it is covered by a thin layer of conglomerate and marly sand, which will be referred to later. Near House 12 of the Old Suez Post Road it has been let down by a fault against the Upper Moqattam beds of the Eocene. Here the beds are tilted away from the fault at the point of greatest throw at an angle of 15°. This forms a syncline with the beds dipping away from the ridge of Awêbed. A dip-fault also breaks the escarpment at this point, and carries it forward about half a kilometre. It is due to this fault, no doubt, that the beds are thrown up into such a sharp dip near the previous line of fracture. It is estimated that there are about 40 metres of white limestone here, and the lower beds are also undoubtedly present, though not well exposed.

Beds of Doubtful Age:—

Near House 12 of the Old Post Road to Suez, a small area of sands, conglomerates and clays is met with. The following is the section of this formation:—

Top.	Flint conglomerate with calcareous cement ...	15 to 17 metres.
2.	Falsebedded grit...	0·5 „
3.	Saliferous clay or marl, greenish in colour, with a fossiliferous band of impure limestone containing the following fossils; *Psammechinus Fuchsi*, Gauth.; *Agassizia Zitteli* Fuchs.; *Pecten cristatocostatus*, Sacco.; *P. Kochi*, Loc.; *Amusium* sp.; with borings of a sponge like *Cliona* in it. *Placuna miocenica*, Fuchs.; *Arca* sp.; *Pectunculus* sp.; *Cardita* sp.; *Cardium multicostatum*, Broc.; *C.* cf. *oblongum*, Chemn.; *Cardium* sp.; *Venus* cf. *islandicoides L.; V. islandicoides; Tapes vetula*, Bast.; *Tapes* sp.; *Tellina lacunosa*, Chemn.; *Mactra subtruncata*, Mont.; *Thracia pubescens*, Pultn.; *T. Bellardi*, Pict.; *Pholadomya Puschi*, Goldf.; *Solen marginatus*, Penn = *S. vagina.; Psammosolen strigillatus*, L.; *Clavagella bacillum*, Brocc.; *Turritella terebralis*, L.; *Ficula* cf. *condita* Brongn.; *Ficula* sp.; *Oliva flammula; Conus* sp.	2 metres.

These fossils were all returned as of Helvetian age by Dr. Blanckenhorn, and as far as palaeontological evidence goes, it would be right to put down the age of this deposit as Middle Miocene. But the field evidence is against this. In the first place, these beds rest very discordantly on Middle Miocene rocks; they have been deposited subsequent to a fault which has shifted the Miocene escarpment forward, and are laid against the upthrow side in a reef-like manner, only the upper conglomeratic bed overtopping the small fault-scarp; they have no affinity lithologically with the Miocene beds, the latter being limestone, undoubtedly of marine origin, while they are fluviomarine. A curious fact is, that nearly all the fossils mentioned, with the exception of *Mactra subtruncata*, were obtained from the lower half of the Miocene beds in the immediate neighbourhood, the fossil abovementioned not having been found previously in the Miocene in any place in Egypt except Siwa. It occurs, however, all through the marine Pliocene of the Lower and Middle stages. Taking into consideration all the observations advanced, the inference to be drawn from them is that the Miocene fossils have been washed into these beds from the neighbouring Helvetian deposits, and that the age of the beds in question is not Helvetian but Middle Pliocene. Beds of this age were found by Schweinfurth in 1899 at the south foot of the Ataqa range, and in these according to Blanckenhorn (1) *Ostrea cucullata* unaccompanied by *Pecten benedictus* occurred together with young *Ostrea digitalina* and a rolled *Pecten concavus* Blanck. The probabilities are thus all in favour of the Pliocene age of the beds near House 12, on the Old Post Road to Suez.

As would be expected from the knowledge that the whole of the Miocene deposits are Mediterranean, a strong unconformity exists between them and the older formation, which becomes more marked as the country is examined from west to east. The subsidence which allowed the entrance of the sea originated in the north-west and gradually travelled southwards during the deposition of the Lower Miocene. Towards the west, denudation of the basalt had not proceeded very far before the latter was submerged and covered by the fluviomarine deposits of the Lower Miocene. Further to the east all the basalt, except on the flanks of the volcanic cones, was removed, while still further on, the Oligocene sands and gravels have been considerably denuded before they were covered by the Miocene. It is difficult to say definitely whether the pure white limestone of the Middle Miocene which is found at Gebel Genefe and round about that neighbourhood, ever existed as such in the vicinity of Cairo. All the evidence seems to point the other way. From Cairo eastward the Middle Miocene beds gradually pass from a gritty limestone into a pure white chalky rock of greater thickness, while the lower beds of sand, pebbles, and grits become gradually changed into impure limestones. It seems to the writer that there is evidence of a fairly quick rise of the sea-floor, in the presence of beds of sands, grits, and pebbles, about 26 metres thick which show remarkable current-bedding, overlie impure limestones, and pass sharply into limestones above except in the vicinity of Gebel Genefe and Awebed. This looks as if there was a long flat anticline, in the district where the sandstone is a characteristic feature, the corresponding trough or syncline being in the neighbourhood of the hills above-mentioned. This would account for the greatly increased thickness of the beds in the latter area, while the sharp passage from the sandstone into limestone in the former district may indicate a sudden deepening of the water once more. The evidence collected by Blanckenhorn (2) at Mogara shows that the

(1) Zeitschr. d. Deutsch. geolog. Gesells. 1901, p. 367.
(2) Loc. cit. pp. 97-99.

Middle Miocene was there of a shallow water type, and this apparently extended to the Cairo-Suez district during the deposition of the lower part of the Helvetian. On the whole, the evidence is against white Helvetian limestone ever having been present in the neighbourhood of Cairo.

Blanckenhorn has stated (1) that the Miocene has been laid against Gebel Ataqa in a reef-like manner, the range having been produced by faulting in pre-Miocene times. This is contrary to the field-evidence. What is seen on examination of the ground passing from the fault-line towards the younger beds is as follows: On the fault lie the Upper Moqattam beds resting against the Lower Moqattam, while following in ascending order come the Oligocene, and then the Miocene. The field relations of these beds are the same here as in the other parts of the area. There is no evidence of a fault prior to Miocene times, but on the contrary the Upper Moqattam, Oligocene, and Miocene beds are all alike bent up towards the fault as if there had been a certain amount of tearing prior to the fracture such as has been described at the west end of Awebed, and are dipping away from the Ataqa ridge. If the statement of Blanckenhorn were correct there ought to be an overlap of the Miocene over the eroded edges of the Eocene, and the beds of the former should be lying horizontal and touching the sides of Gebel Ataqa. Such is not the case, and the writer is compelled by the evidence at his disposal to state that the Miocene has been let down into its present position, and that no evidence of pre-Miocene faulting exists in this district.

(1) Loc. cit. p. 63.

CHAPTER IV.

OLIGOCENE.

THE beds which are put in this formation are found all over the district under description, wherever the younger Miocene beds have been removed. They occupy the space between the Upper Moqattam beds and the basalt flows, or, where the latter are absent, the Miocene beds, but in no single instance have they been found resting directly on the Lower Moqattam. In character, these beds are somewhat variable in different places, but as a whole they possess the appearance of deposits which have been laid down during a Continental period. Turning to the detailed description of the various exposures the first to be noticed is Gebel Ahmar.

Gebel Ahmar.—This hill derives its name from its general red colour. It is situated at the extreme north end of Gebel Moqattam and is evidently the remains of a geyser which at one time poured forth its warm silicated water after the deposition of the sands and gravels of the Petrified Forest. It is composed of a silicified sandstone or quartzite using the latter name in a loose way. Speaking correctly it is composed of layers of sand and pebbles set in a matrix of chalcedonic silica. In places strong falsebedding can be seen; while in others pockets of loose sand are occasionally noted. The prevailing colour of the stone is an ochreous brown or red; but some of it again is almost as black as basalt. It breaks very readily and with a somewhat splintery fracture, and on a fresh fracture has the peculiar, watery lustre characteristic of silica. It is quarried for millstones, but a good deal of the stone is used in building the lower part of the walls in damp situations to counteract the effects of the salts which rise up from below and tend to disintegrate the limestone. It is also used as macadam on certain of the roads in Cairo.

On the top of Gebel Moqattam are the remains of an old geyser named by German geologists "Rennebaum's Volcano." This is a black conical mound basin-shaped at the top, and consisting of a black silicated grit. This shows lines of silicification sloping in towards the centre. A shaft has been sunk by some one which shows the junction between the limestone and the sandstone. At the junction the limestone is much decomposed and is of all shades of colour from brown to purple. In places it has the appearance of mortar owing to the admixture of sand.

A little to the north of the Moqattam some red hills rise up in a more or less isolated fashion out of the confused mass of gravel and sandy mounds. These are the hills known as "Gebel Kreibun." They consist of fine sand of various colours, consolidated in places into sandstone, while in others they form a sandy marl by the increase of clay. These sandstones are strongly falsebedded and bear a strong resemblance to the Gebel Ahmar stone. These hills owe their existence to the presence of a hard plug of silicified rock in their centre which enables them to withstand denudation. In this plug lines of silicification are seen dipping towards the centre. This,with a sort of basin-like depression, suggests that these hills are the stumps of geysers. At their foot in the low ground many beautiful shades of coloured sands are found. They range from pure white through yellow and red to purple. On the south side of these hills there is a white sandstone at their base with a slight westerly inclination. In thickness the whole of this series is from 33 to 35 metres.

To the south of House No. 3 on the Old Post Road and underlying the basalt, there is a grit underlaid by pure white sand.

Along the north edge of the plateau of the Moqattam there are the remains of a geyser. Here the limestone is always rotten looking, and iron-stained like the sandstone, while the lines of colouring run either vertically or at a steep angle to the throat of the geyser.

At the place where the plateau of the Moqattam merges into the general trend of the ground is the beginning of the Petrified Forest. Here Oligocene sands and fossil wood cover the Eocene limestone, while the remains of a geyser is seen in a small hill near by. The ridge of silicified sandstone which runs northwest from this point is evidently a continuation of the fissure noted along the foot of the Moqattam and culminates in "Rennebaum's Volcano." Out of this fissure issued the silicated waters which petrified the trees lying in the sands. This ridge of silicified sandstone occupies the highest point in the Petrified Forest of the present day, and it seems likely that the difference in height between it and the surrounding country might be taken as representing the thickness of the original beds which have been denuded away. To the south of this ridge are many pieces of silicified wood and trunks of trees, some of which were 16 metres long and proportionately thick. It is to be noted that, in the district under consideration, no fossil wood has ever been found in any quantity except in the neighbourhood of geysers or geyser fissures.

The following are the genera and species of the different silicified trees found here.

Araucarioxylon Aegyptiacum	Krauss in Unger.
Palmyloxylon Aschersoni	Schenk.
Nicolia Aegyptiaca..	Unger.
Laurinoxylon primigenium	
Acacioxylon antiquum	Schenk.
Capparidoxylon Geinitzi	
Dombeyoxylon Aegyptiacum	
Ficoxylon cretaceum	Schenk.

Near the southern edge of this fossil tree area and about 1·5 kilometres N.W. of the excavation known as Bir el Fahm, the following section was seen:—

Top.	Sand and gravel containing much fossil wood..	13 metres.
2.	Variegated sands, red, white, and yellow... ...	7 „

The sands contained a good deal of salt which had bound them into a hard crust on the surface.

Gebel Ansuri.—To the west of Gebel Ansuri, Oligocene beds come between the Eocene and the Miocene, and are seen to pass under the basalt. Here there is a plugged-up fissure out of which silicated waters evidently issued; it is now marked by a narrow, dykelike mass of silicified sandstone. On the top of the Eocene hill there are also the remains of a geyser in the form of a rounded plug, representing undoubtedly the neck.

Gebel el Angobia.—Along the west of the ridge of El Angobia are several filled-up fissures of thermal springs. These occur along the junction line of the Oligocene and Eocene. All round this ridge are seen the denuded plugs of various fissures, and it would seem that, in the formation of the ridge, cracks had been produced, up which the thermal waters came. In places where the basalt appears to the north of El Angobia, geyser pipes are seen in the Oligocene overlaid by the former rock. Further north geyser pipes appear like small islands at this point in the lowest beds of the Miocene. It is to be noted, however, that the evidence is all against these geysers having been in action after these beds were deposited. There is no sign of alteration by thermal waters; but the beds are laid around these pipes as if they had been deposited subsequent to the filling up of the pipes.

Along the northern edge of El Angobia where the fault has thrown down the Miocene, there is a fairly perfect geyser cone on the upthrow side of the fault. It still preserves its conical appearance and is composed of a plug of silicified grit surrounded by looser sandy beds. Its sides are covered with loose blocks of the silicified grit which have been broken off by the changes of temperature.

Gebel Ali Hamum el Azraq or Amuna.—This is a prominent hill standing about 5 kilometres N.W. of Bir Gendali. It is composed entirely of sand and gravel laid discordantly on the Upper Moqattam beds. On account of the amount of scree, a section could not be made out, but near the base were seen pieces of a ferruginous grit. This hill, no doubt, takes its name from its peculiar purple colour under certain conditions of light.

About 12 kilometres N.E. of Bir Gendali the Oligocene is cut off by a fault which throws the Miocene beds down against it. This fault eventually cuts off the Oligocene in the neighbourhood of Gebel Qatamia.

Gebel Qatamia. About 9 kilometres N.E. of Bir Gendali are some geyser pipes connected with a basalt dyke. These are faulted into the Lower Moqattam by a trough-fault, one of the faults bisecting a geyser cone and thus helping to fix the date of the fracture.

This Oligocene is a continuation of the Petrified Forest and has an east and west extension of 50 kilometres, and a width of 8 kilometres at its widest point, viz., the eastern boundary of the Petrified Forest. From that point it narrows rapidly to a strip about 3·5 kilometres wide.

The next place where Oligocene beds are met with is in the sand and gravel ridge to the north of Houses Nos. 6 and 7, and on which the ruined Palace of Der el Beda stands. This ridge is bounded by faults on all sides, which have let down the Miocene beds against it. In it pieces of fossil wood and the remains of filled-up fissures are met with. A characteristic of the Oligocene is the presence of numerous burrows of jerbils, etc., in it. This often helps to show what is underneath a down wash, and has been found to be a useful indicator of the presence of Oligocene beds. The explanation of the preference of these animals for Oligocene beds is found in the ease with which they can dig into the sands as compared with the more compact Miocene rocks.

Another point noticed at this place is the replacement of the pure sand met with further to the west, by a finer and more clayey variety; a tendency to become more consolidated is also seen here. It may be that here are deeper water conditions than existed to the west.

A little to the east of Der el Beda, the fault which bounds this ridge on the north side is cut off by a dip-fault, and from this point eastward to Gebel Awebed the Oligocene occupies its normal position with reference to the Miocene. At 11·5 kilos. east of Der el Beda, the stump of an old volcano rises through the Eocene and Oligocene rocks (¹). These beds are much more consolidated than heretofore, and there is a greater frequency in the occurrence of geyser pipes in the vicinity of the volcanoes. Where not consolidated these beds consist of white and yellow sands with a few pebbles scattered through them. On the west of the volcano the basalt overlies the Oligocene beds and passes under the Miocene rocks. The fault which forms the southern boundary of this area, continues to the eastward and becomes one with that bounding Gebel Awebed, being at the same time the boundary of the big plain to the south. The total area of this exposure of Oligocene is 36 by 3 kilometres.

The next area is perhaps the largest met with in this district. It occupies the wide, shallow valley which extends towards the Birket el Hag, and in which lies the Old Railway line to Suez. To the north it passes out by Wadi Gafra into the large plain known as El Hammad, which it apparently forms. In the valley are two outliers of Miocene which have been faulted against the Oligocene; while to the north of them it appears in the plain and again disappears under the Miocene. Further west there are some sand-dunes formed in the middle of the valley, one of which is of considerable size. These are called "Kataban" by the Bedawin.

Along the southern edge of this area where the railway passes through a small inlier of these beds near the Middle Station, a section of falsebedded sands and grit cemented together by ferruginous material is seen, and silicified sandstone appears at the surface in the form of a narrow vein by the line of fault. Nearer the Railway Station the beds become very much crushed and are nearly vertical owing to the action of a dip-fault which throws forward the Miocene to the north. On account of the neighbourhood of the fault it was difficult to be certain of getting a correct measurement of these beds so it was not attempted.

To the north and east of the Miocene outliers and between them and Gebel Um Qamr the Oligocene has a black ferruginous bed at the surface. It consists of sand, grit, and some quartzite pebbles bound together by a silico-ferruginous cement. From this rock some fine

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(¹) See Section III.

PLATE IV.

Geyser plug on Gebel Gafra showing etching by wind-borne sand.

examples of sand and wind action can be obtained, the harder quartzite pebbles standing out in relief from the softer matrix. Some extremely grotesque shapes are produced by the unequal wearing of this stone under the sand-blast. Standing vertically in this area are the remains of numerous geyser pipes, from which doubtless issued the thermal water which cemented the sand together. To the east of Gebel Um Qamr, the Oligocene forms the characteristic tumbled mass of low gravel hills so often found in this formation.

Gebel Gafra.—Further to the east and on the other side of Wadi Gafra is Gebel Gafra which is in reality a dome of Eocene limestone overlaid by Oligocene beds. The Oligocene is connected with that lying in the valley just described by a narrow tongue. At the west end it disappears under the Miocene, but towards the east it rises up and covers the Eocene. On the south side the Eocene is exposed along the crest of the ridge, while only a thin coating of Oligocene beds is found at the foot where it is cut off by the fault which throws the Miocene down against it. Further west it is also carried forward in a southwesterly direction by a dip-fault. On the north flank of Gebel Gafra the Oligocene is only in patches, mixed with Miocene which is let into it in places by a trough-fault.

At Gebel Gafeisad or Agleiat Qamr (1) there is the neck of an old volcano rising through the Oligocene. In the middle of the cone is a large plug of silicified sandstone, evidently the remains of a geyser, while on its flanks are numerous filled-up fissures radiating from a centre. It would seem as though the vent of the old volcano, after the lava had ceased to be poured out from it, was used as an exit for the thermal waters which issued at this point. The Oligocene beds cover a good part of Gebel Gafra and numerous stumps of geysers and filled-up geyser fissures are seen in it. Some of these being exposed to wind and sand action have had their structure brought out by etching (2). In the middle of the plateau the upper and coarser beds of the Oligocene have been removed, leaving the finer gravel and sands which form the lower beds. Here it seems that the Oligocene consists of coarse gravel at the top which gradually becomes finer as the lower beds are exposed, until it is a fine sand of various colours. No fossil trees are seen in the upper beds, but in the finer gravels and sands they are plentiful. On account of the incoherent character of these beds and their elevated position, they have been nearly all carried away by the denuding agents. Wherever Miocene

(1) See Section III.
(2) See Plate IV.

beds appear on the slope they have acted as a protection and a retarding agent to this denudation. At one point where the Miocene has been faulted down against the Oligocene there is a geyser cone on the edge of the upthrow side of the fault. Here the breaking up of the cone has caused the strewing of pieces of silicious grit over the Miocene. It is on this that Blanckenhorn (1) (who drew a good deal of his information from L. Smith's field-maps of this district) founds his assertion that thermal action was going on in Miocene times. These geyser necks are either standing out in relief like "Sarsen Stones" or are marked by a heap of pieces of silicified grit, the latter being the result of the unequal expansion and contraction of the stone.

In Gebel Gafra the total thickness of the Oligocene is between 50 and 60 metres.

The continuation of the Oligocene to the east after leaving Gebel Gafra is the tumbled mass of gravel hills to the east of the middle volcanic neck, i.e., the neck lying on the line between Gebel Gafeisad or Agleiat Qamr and the volcanic stump 11·5 kilometres east of Der el Beda. In these gravel hills are fossil wood and patches of silicified sandstone. Nearer the basalt neck numerous fissures plugged with silicified sandstone were met with, as well as geyser necks, while silicified wood was very abundant. In this neighbourhood nearly all the sands have been consolidated into siliceous sandstone by the warm silicated waters. At the basalt neck there is a large filled-up fissure of quartzite or silicified sandstone (2) standing up like a dyke which rises through the basalt. This has undoubtedly been a fissure up which the hot waters rose after the volcano became quiescent.

East of Gebel Gafeisad the Oligocene forms a sharp line with the basalt; it appears to be dipping steeply but this is perhaps only falsebedding. The cause of the hardening of the sand on the flanks of the hill may be due to two causes, viz; contact metamorphism, or warm silicated waters, but to which of these it is due it is difficult to say. On the flank of the hill is a large plug of silicified sandstone which stands up in the Miocene beds like a small island. No alteration was seen in these beds, and the geyser must therefore be Pre-Helvetian in age. To the east of this hill, the Oligocene runs away in a long narrow tongue brought up by a double fault through the Miocene, which is let down on its north and south flanks. It is seen in places, after the faults have died out, lying on the top of an anticline in the Miocene

(1) "Das Miocän." Zeitschr. d. Deutsch. Geol. Gesells., 1901.
(2) See Section III.

to the west of El Gherbe. Immediately to the east of Gafeisad numerous geyser necks and fissures are seen associated with fossil wood. A little way beyond the geyser area a section of the Oligocene was seen, consisting of the following beds:—

Top.	Clayey Sands...	3	metres.
2.	Ferruginous Sands, black, red, and brown ...	3	"
3.	Yellow Sands	2·4	"
4.	Marly Sands...	1·8	"
		10·2	metres.

East of El Gherbe.—To the east of El Ghêrbe the Oligocene is again brought up on an anticline having the Miocene on either side. Further east a fault has thrown down the Miocene to the north thus cutting out the Oligocene. From the top of the ridge of Eocene, the Oligocene has been washed away, and at this point the Oligocene has nearly nipped out. This is either due to overlap or a difference in dip in the ridge. It is more likely a combination of these two causes. That there is overlap is shown by the difference of the beds which form the apparent base of the Miocene; while the difference in dip would account for the varying width of outcrop. Another explanation for the latter phenomenon is that the narrow part of the outcrop falls on a node of the two sets of folds which occur in this area, viz., those having their axis lying in a S.W.–N.E. line, and the others more or less at right angles to this line—N.W.–S.E.

The Oligocene is never present in any thickness in this area, and only serves as a mask for the Eocene. The absence of a protecting layer of basalt is perhaps accountable for this.

After being nearly nipped out, the Oligocene suddenly expands considerably in outcrop, then narrows down and expands again, only to be contracted again in the neighbourhood of the peak of Miocene limestone known by the name of "Fuchsberg" in German publications. Beyond this hill it opens out considerably, although the evidence of the two sets of folds is still seen in the small dome-like inliers of Eocene limestone which appear in it. To the east of the main outcrop of the Oligocene where it swings round towards the south-east, a series of outliers of Upper Moqattam beds capped by Oligocene are met with. These are the result of three step-faults throwing down to the north-east.

Gebel Shab'rawet.—At the foot of this hill are two patches of Oligocene beds containing fossil wood and some geyser plugs, which have been let down by faults. To the east of the hill one or two small exposures of these beds occur along the foot of the Miocene cliff of Gebel Faid.

Gebel Genefe.—At the foot of Gebel Genefe there occur one or two geyser plugs along the edge of a line of fault. A small patch of Oligocene gravel has been let down on a piece of Upper Moqattam which is lying between the Lower Mcqattam and the Miocene. (See Section 1.) The Oligccene forms a thin covering on the Upper Mcqattam on the east flank of Gebel Genefe. Here its outcrop is very narrow, but it soon widens out, and after passing Gebel "Fuchsberg" on the west it disappears under the Miocene. On its western border near the Old Cairo-Suez Railway it is cut off by a fault which throws the Miocene down against it to the west. A little complicated faulting has taken place here; the Miocene has been let into the Oligocene by a trough-fault, while a little further beyond a dip-fault the throw is reversed, the Miocene falling to the east.

Gebel Awebed.—At the west end of this hill a small patch of Oligocene occurs on the north side on the downthrow side of the two faults and lying in the angle formed by the meeting of the two fractures. Here the following section was seen in a small ridge:—

Top.	Yellow falsebedded sand	3	metres.
2.	Conglomerate	0·5	„
3.	Dark brown to yellow falsebedded sand ...	3·0	„
	Total	6·5	metres.

There is a slight dip to the north, and the conglomerate bed thins out rapidly and disappears. Small faults were seen in these beds. On the south side it comes up on a fold and disappears under the Miocene being then faulted down against the Lower Moqattam. (1) Along this line of fracture occur some reddish-brown hills of silicified grit which are the remains of a geyser. Further to the east where this line of fracture ceases, another patch of Oligccene is found on the downthrow side of the fault bounding the south side of Gebel Awebed.

The only other place were Oligocene beds were met with in this area is in a long narrow strip on the downthrow side of the fault which runs along the foot of the ranges of Gebel Um Thibua and Ataqa. It occurs in its normal position between the Eocene and the Miocene, but is eventually nipped out by a second fault which runs along the edge of the foot-hills of the latter range.

In view of the discussion of the age of these beds, the following points should be borne in mind:—

1st, that these beds overlie the Upper Moqattam in a discordant

(1) See Section V.

Moqattam. They have never been found lying directly on Lower Moqattam beds; therefore denudation had not proceeded as far as to completely remove the Upper Moqattam beds.

2nd, They were deposited prior to the earth-movements mentioned above, which threw the country into a series of N.E.–S.W. and N.W.–S.E. folds. These folds are not seen in the Miocene limestones (Helvetian); they are at least Pre-Helvetian and in all probability Pre-Miocene in age.

3rd, Where they have not been protected by the basalt, these beds have undergone considerable denudation, which has reduced their thickness from at least 40 metres to 5 metres; this has all taken place previous to the deposition of the Helvetian.

4th, Wherever basalt flows occur these always come between the Miocene and the Eocene. It is to be remembered that the basalt was erupted during a continental period when scoriae and tuff would be thrown out; yet in none of the flows is there the slightest evidence of these things. This argues against the supposition that these lava-flows might be Lower Miocene, as in that case the tuffs ought to have been preserved. As a matter of fact there is much evidence of unconformability and overlap between the basalt and Helvetian, as well as the Lower Miocene.

5th, As has been shown, the geysers and thermal springs are subsequent to the basalt. This points to a considerable lapse of time from the outpouring of the lavas to the dying out of the volcanoes, since the geysers and thermal springs in many cases have formed on the cones of the volcanoes. Might not the earth-movements which gave rise to the above-mentioned folds and faults mark the beginning of the geysers and thermal springs by producing the fissures up which the heated waters rose?

6th, The geysers and thermal springs had died out before the deposition of the Helvetian and Lower Miocene beds as the denuded necks and stumps of some of them are found in the lower strata of this age, but *no trace of alteration or silicification* has been noted in these places.

7th, The silicification of the trees took place before Helvetian times, and the numerous cracks in the basalt filled with chalcedony, etc., are an incidental proof of the siliceous character of the water. The association of geyser necks, thermal springs, and silicified trees noted in so many places cannot be regarded as accidental, but must rather be taken as a proof of the view that the thermal waters were the means of preserving the trees in the sands where they were deposited, while in the places where no geysers were at work the trees decayed and disappeared in the percolating waters. The fact that these trees had been deposited for some time before the geysers came into action, would account for the unsatisfactory condition of so many of the specimens found.

8th, In nearly every instance where the silicified trees have been examined the bark is absent; there are no branches, (only one or two cases have been noted where the nodes which represent the branch-origin have been seen); no roots have been noted except one case of a bamboo which was found bearing them. This supports the view that the trees have been drifted into their present position and there silicified.

9th, This formation is of fluviatile origin, and must have been formed during a continental period, when the land was clothed with forests from which the trees were drifted into the basin or estuary in which the sands were being deposited.

10th, The beds with silicified trees underlie the basalt flows, which in their turn are overlain by Lower Miocene beds in a discordant manner. Their age is thus probably Lower Oligocene.

Age of these beds.—Gebel Ahmar and the surrounding hills have attracted the attention of many observers such as Russeger, Orlebar, O. Fraas, Schweinfurth, Mayer-Eymar, Sickenberger, Fourtau, and Blanckenhorn.

In 1845, Orlebar (1) claimed to have found the Gebel Ahmar Sandstone at Station No. 3 (No. 4 of the writer's) on the Old Post Road to Suez, overlying Miocene beds with *Scutella Zitteli.*

O. Fraas (2) imagined he could trace a gradual passage between the Upper Moqattam and these beds, and concluded they were marine and of Lower Oligocene age, as they had undergone the same general earth-movements as the Eocene beds.

Schweinfurth (3) discussing the age and origin of these beds, says that there are two reasons why these beds are not marine:—

1st, They occur at different heights in various localities; and 2nd, they rest on a very uneven surface which does not differ much from the present day relief of the surface. He makes a point of what he considered to be a fact, viz., that the present day relief of the surface had already been inaugurated before these beds were laid down.

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(1) "Some observations on the geology of the district between Cairo and Suez." Jour. Roy. Asiatic Soc., 1845.

(2) "Aus dem Orient," 1867. pp. 157-8.

(3) "Geolog. Schichtenliederung d. Mokattam." Zeitschr. d. Deutsch. Geolog. Gesells., 1883, p. 719 et seq.

He also calls attention to the resemblance existing between the Pliocene Sands in the Nile valley and these beds, and finally groups them together in his map as (?) Pliocene.

Discussing O. Fraas's views, he objects to the theory of a gradual passage from Upper Moqattam to Gebel Ahmar beds that there is no evidence of limestone and clay in the latter. They have no affinity with the Moqattam beds but closely resemble the Pholas Sands at the foot of that range. His own observations are entirely against the gradual passage theory, as he found that the Gebel Ahmar beds did not lie on the uppermost beds of the Moqattam, *but were found overlying various beds in different places*. This, to his mind, was a proof of the freshwater character of this deposit. He winds up a very carefully reasoned paper with the following conclusions:—

1st. All trunks are horizontal in the Petrified Forest. Only Figari Bey is reported to have found one erect. No excavation has been made to see if any are in that condition, but there seems to be no reason to think that the trunks are *in situ*.

2nd. No bark has been seen on the trunks, therefore they have not been silicified before they had decomposed.

3rd. Many trunks appear to have been enclosed in sand after silicification.

4th. No branches or roots have been found in the district near Cairo.

5th. Stems have been found with nodes on them.

He points out that there is an absence of stratification in the beds, and concludes that the silicification must have taken place in a series of basins because of the different levels at which the trees lie. Sickenberger (1) regarded Gebel Ahmar as of Miocene age. Mayer-Eymar (2) says that after the Tongrian Sea had retired and the volcanoes had become extinct, the country became covered by dense forests of trees for the most part of the Order Sterculiaceæ and the species *Nicolia aegyptiaca*, Unger. Then the subterranean waters, arrested either by the Senonian fold of Ataqa-Abu Roash, or by internal volcanic masses and heated by the latter, burst out to the right and left from below the river of that period, and under the form of warm siliceous springs, bathed the foot of the trees wherever there was any depression. The trees were thus silicified *in situ*. The age of the Petrified Forest he makes later than the basalt. He does not think that Gebel Ahmar is the product of geyser action, or that geysers did actually exist, the

(1) "Three lectures on the Geology of Egypt." 1891.
(2) Bull. de l'Institut Egyptien. 1893, p. 375 et seq.

various peaks of quartzite being in each case the product of a strong thermal spring.

Fourtau ([1]) regards Gebel Ahmar and Kreibun as the product of true geysers, and puts them and the silicified forest down as Pliocene in age.

Blanckenhorn ([2]) considers that geysers such as those of Yellowstone Park were not necessary to the formation of Gebel Ahmar Sandstone; hot springs are capable of doing all that is required. He imagines dunes and marshes, freshwater basins or lagoons containing silica and sand which were borne by fluviatile or aeolian agents and disposed in an irregular manner in the neighbourhood of the springs. These were cemented together by the silica contained in the water. He puts the Gebel Ahmar Sandstone into the Oligocene while the silicified forests he makes Lower Miocene in many places.

Such are the opinions of the different observers. It will be seen that there is not much unanimity amongst them; some of them placing these beds in the Oligocene, others in the Miocene, while still other observers make these deposits of Pliocene age.

A glance at the summary given at the end of the detailed description of these rocks will show that there is little doubt as to the Oligocene age of the fossil wood and the Gebel Ahmar Sandstone. They underlie the basalt which in turn is overlain by Lower Miocene rocks, a strong unconformability existing between the two latter. This does away with the idea of the wood being of Lower Miocene age. Blanckenhorn ([3]) puts the thermal springs into three periods, viz:—Oligocene as in Baharia, etc., Lower Miocene but not sharply marked off from the first, and Pliocene. With the two latter no connection exists in this district. The thermal action followed the volcanic eruption, and both of these were prior to the Lower Miocene. It has been claimed that geysers have been found in the Miocene rocks, but these are in all cases the denuded stumps on which the beds are laid. This being so, it becomes impossible to admit the Lower Miocene age of the silicified wood as claimed by Blanckenhorn. Any of the trees seen in the Lower Miocene beds in this district presented the appearance of having been moved after silicification, and had been in all probability drifted in from the adjacent Oligocene on which these beds lie discordantly.

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(1) "Étude géol. sur le Gebel Ahmar." L'Institut Égyptien, Decembre 1894. et "L'Age des Forêts pétrifiées des déserts d'Egypte," Bull. de la Société Khédivial de Géographie, Série V, No. 2, 1898.

(2) "Das Oligocän." Zeitschr. d. Geolog. Gesell., 1900. p. 477-8.

(3) Loc. cit.

With the idea expressed by some previous observers that the silicification of the sandstone is mainly due to thermal springs and not to geysers the writer agrees, but he claims that geysers did exist as well, e.g.:— Rennebaum's volcano, Gebel Ahmar, Gebel Kreibun, a hill in El Kheshan, Wadi Gendali, and near the west foot of Gebel Awebed, etc. In the first named there is the throat still in existence which will admit a man ; on Gebel Kreibun there are the remains of the basin round the throat, with falsebedding seen in the walls dipping towards the centre.

Origin of the sands and trees:—As far as the writer knows, Schweinfurth (1) is the only observer who has attempted to explain the origin of these beds. He suggests that the sands have been derived from the high hill-mass of Sinai and neighbourhood, and brought to their present position by fluviatile action.

It was undoubtedly a continental period for this particular part of the globe during the deposition of these beds, and the rocks exposed at the surface were undergoing rapid degradation. It seems to the writer that these sands have been derived from the breaking up of an already existing sandstone and other sedimentary rocks. The pure white, yellow, brown and red sand known in these beds could all be derived from the Nubian Sandstone as beds of those shades of colour occur in that rock; while the pebbles of chalcedony, flint, etc., might be derived from the siliceous beds or from the flinty layers of the Cretaceous limestones.

When it comes to pointing out the point of origin of these sands it is a more difficult matter. It may be that there existed at that time a big fold extending from Baharia through Abu Roash to Shabrawet, which by denudation exposed the Nubian Sandstone and thus supplied the sand. Of the existence of such a fold there is some evidence, but that is rather meagre. The source of these sands must therefore be left an open question, until further evidence can be collected.

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(1) Loc. cit.

CHAPTER V.

EOCENE.

THE beds belonging to this horizon in this area have been studied with more or less minuteness by different observers in Gebel Moqattam. Of these, perhaps the most noteworthy as being the pioneer worker, is Professor G. Schweinfurth (1) who was the first to attempt the correlation of the beds and to divide them into Upper and Lower Moqattam series. The following is a synopsis of his classification:—

UPPER MOQATTAM.

Top layer: A.A.A. α Beds containing *Nummulites Beaumonti*, *Agassizia gibberula*, and some other echinids, besides *Echinolampas Fraasi*, which is the characteristic fossil.

2nd. A.A.A. β. Beds containing only some *Lucina*.

3rd. A.A.A. γ. & δ. Breccia of *Plicatula polymorpha* 1 to 1·5 metres thick. Then beds containing *Agassizia gibberula*; *Echinocyamus Luciana*, *Echinolampas sp.* and a variety of *Ostrea Clot-Beyi*, as well as *Callianassa* claws.

4th. A.A.A. δ. Beds containing *Ostrea Clot-Beyi* and *Carolia*.

5th. A.A.A. 1. Beds containing *N.* (?) *Beaumonti*; *Agassizia gibberula*; and also *Plicatula polymorpha* and a few small gasteropods.

This stage as a whole is estimated to be between 60 and 70 metres thick.

LOWER MOQATTAM.

Top A.A. Beds containing *Echinanthus libycus*; *Echinolampas Osiris*; *Amblypygus dilatatus*; and *Lobocarcinus*.

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(1) "Geol. Schichtengliederung d. Mokattam." Zeitschr. d. Deutsch. Geolog. Gesells, 1883, S. 709 et seq.

2nd. A.1. α. The upper beds contain *Lobocarcinus Paulino-Wurtembergensis;* while below these come internal casts of *Cerithium giganteum;* and lower down *Nummulites Gizehensis; Echinolampas Fraasi; E. Africanus; E. stelliferus; Echinopsis libyca; Micropsis Mokattamensis; Eupatagus formosus; Schizaster Jordani; S. foveatus; S. Mokattamensis; Porocidaris Schmiedeli.*

3rd. A.1.b. A.1.c. A.1.d. Beds containing *Porocidaris Schmiedeli* spines.

4th. A.1.e. Beds containing spines of *Porocidaris Schmiedeli,* a large *Serpula,* and teeth of *Carcharodon* and *Lamna.*

M. Fourtau (1) published a short paper in which he gave a diagrammatic section through the Moqattam, but as thicknesses were not noted it is difficult to compare his divisions with those in measured sections. In this paper a very full list of fossils is given which he collected from the various beds.

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(1) "Note sur la stratigraphie du Mokattam." Bull. Soc. Geol. France (3) XXV., p. 208, 1897.

The following table taken from Dr. Blanckenhorn's book (*) *shows the classification and correlation with approximate thicknesses of the upper Moqattam series of the principal writers on these rocks* :—

Order of Succession	General Characters Blanckenhorn's Classification	DESCRIPTION OF THE BEDS	Schweinfurth's Classification	Mayer-Eymar's older and Sickenberger's Classification	Mayer-Eymar's Newest Classification
Top. II. 8	3·50–20 metres hard limestone with casts of *Cardium* 2 sp.; *Lucina, Turritella* 2-3 sp.; no *Carolia*, few *Plicatula* ...	1·50–2 metres yellow, hard calcareous Sandstone ... ... 4 m. spongy limestone with *Echinolampas Crameri, Anisaster gibberulus* and casts of *Cardium, Cardita, Spondylus, Rostellaria, Natica* ... ... } At Ên Musa; 14 met. *Turritella*, 3 sp. and other gastropods, *Spondylus, Ostrea, Cardium*. 0·50–1·50 m. beds with marly partings... ... ... 2–3 m. calcareous sandstone with *Vulsella, Ostrea Fraasi, Lucina, Cardium*, 2 sp. *Spondylus, Turritella*, 2 sp.	AAAα	e d	e .d
7	6–8 m. variegated clay.	0·50–2·50 m. variegated, brick-red, violet, ochre and blue-green potter's clay, clay, and sand with gypsum ... ... 0·30–1 m. ochre-yellow bed with *Cardium, Turritella* and bones ... ... 3–5 m. blue and ochre-yellow clay and sand		c	
6	3–6 m. sandy limestone with *Vulsella, Carolia, Turritella*. Upper Carolia horizon	0·5 m. yellow limestone ... ... } 1 m. limestone in 2 beds. 0·5 m. beds with marly partings ... } 2–2·60 m. sandy limestone or sandstone, the upper surface pierced by pseudo-mussel borings. *Carolia, Ostrea, Vulsella*, a few casts of *Lucina, Natica, Gisortia, Turritella*. Further east above beds are represented by 6 m. sandy limestone	AAAβ		c
5	2 m. oyster beds and gypseous marl (thin coal and oyster horizon) ...	0·40–1 m. marl, clay, or spongy, porous sandstone with pseudo-borings ... ... 0·30–0·80 m. oyster bed with *Ostrea elegans, O. Fraasi* and one other species with thick shell and deep muscle scar, *Carolia, Plicatula, Vulsella, Turritella*			

4	3 m. *Plicatula* horizon.	[illegible] *tula polymorpha, Vulsella, Ostrea* (scarce), *Arca, Pectunculus, Cardium, Mactra, Turritella obruta, Cassidaria, Natica, Xenophora, Rimella, Terebellum, Anisaster gibberulus, Thagastea Luciani* (few or no *Carolia*) ... ... 1–1.80 m. yellow marl, sand and limestone with gypsum ...	AAAγ		b
3	2–2·50 m. Lower *Carolia* horizon.	0·80 m. marly limestone with *Carolia* 0·70–1 m. bed with *Nummulites Beaumonti, Ostrea Clot-Beyi, Turritella*, bones of turtles, and Cetacea... 2·50 m. overhanging bank of dark, sandy limestone with *Nummulites Beaumonti, Carolia, Spondylus*	AAAδ	a	aγ
2	5·50 m. Region of small nummulites and gastropod banks	0·90–1 m. beds with sandy partings deeply coloured... ... ... 1·30–2 m. friable sandstone ... ... 2 m. marl... ... ... 0·50–1·50 m. yellowish white limestone with *Nummulites Beaumonti, N. Schweinfurthi, N. discorbina and N. subdiscorbina, Mactra depressa, Cardium Schweinfurthi, Cytherea parisiensis, Solarium, Cerithium, Turritella* and many other gastropods ...	AAA 1.		
1	9 m. Gypseous clay and Tafla with celestine.	7 m. yellowish and ashgray marl with gypsum and celestine. 0.50 m. dense clayey limestone			β
		0·50–0·80 m. ochreous, green-banded "Tafla" with celestine. 0·50 m. white marly limestone with gypsum, sometimes with many nummulites	AA.		α
	Total 40–50 m.				

(*) "Neues zur Geol. u. Paläontologie Aegyptens" "Das Eocän." Zeitschr. d. Deutsch. Geolog. Gesells., 1900, z. s. 440.

In the following year Blanckenhorn ([1]) published a paper in which he showed that the plateau of the Moqattam is broken by a line of fault running east and west by which the beds composing that hill have been let down 12 metres.

From the Fayum the following section of Dr. Blanckenhorn's ([2]) is taken for comparison :—

Profile of Gebel Akhdar, 1½ day's march N.N.E. of Qasr el Sagha and E.N.E. of Schweinfurth Plateau.

	Top.	70 metres of Oligocene beds.	
	(c)	Yellow limestone with *Melania Nysti and Cerithium conjunctum*	8-10 metres.
UPPER EOCENE.		White limestone	
		White sand	
		Red sand, sandstone and silica with bones of turtles	
		Alternations of chalky, ochre-yellow marly limestone with calcite druses, white and red sand, sandstone, silica and variegated clay.	40 „
	(a)	Silica, gray and red sand, sandstone (concretionary), ironstone layers and green clay containing silicified tree trunks. Accompanying these are silicified bones of crocodiles, *Podocnemis; Palæomastodon; Ancodus Gorringei; Hyænodon?*	25 „
	II. 8.	Yellow white limestone with *Echinolampus Crameri*	1-1 ½ „
	7.	Gray-green clay and white sand beds, clay containing veins of fibrous gypsum	13 „
	6.	White carolia limestone	
	5b.	Dark clay, bones, white sandstone, Fish horizon; sandstone with *Pristis, Myliobates, Otodus*	
	5 a.	3 Terraces with banks of *Ostrea elegans*, and *Turritella*, marl (higher bone horizon) with snake's vertebræ (*Mœriophis Schweinfurthi* Andr.), turtle remains, and crocodile. Yellowish-red, crumbling marl bank, 2-4 centimetres black and white sand layer, 5 centimetres marl with bones, 1 metre white sandstone or gray clay, (lower bone horizon), with bones of fishes, *Mœriophis*, Crocodile, Whale, jaw of *Zeuglodon* cf. *Osiris*, Dames, and under jaw of *Mœritherium Lyonsi*, Andr.	

([1]) Zeitschr. d. Deutsch. geolog. Gesells, 1901, S. 332-3.

([2]) Sitzungsb. d. Mathem-phys. Classe d. kgl. bayer. Akad. d. Wissensch. 1902, Bd. XXXII Hft. III, S. 406-407, u. 382-383.

As the district included in the map only took in the north face of the Moqattam, the Lower Moqattam limestone, in which nearly all the quarries of Cairo occur, was not examined as it is now cut back into sheer cliffs by the quarrymen which makes a detailed examination impossible.

The northern face only was inspected and sections measured which proved to be composed entirely of Upper Moqattam beds. The following is a section measured in the cliff at the mouth of the small wadi in which Ên Musa occurs:—

Top.	Pinkish dolomitic rock (upper part worked for millstones) passing into white limestone at the base, the latter yielding *Echinolampas Crameri,* de Loriol; *Anisaster gibberulus*, Mich.; *Pecten Caillaudi*, n. sp. Oppenh.; *Spondylus Aegyptiacus,* Newt.; *Cardita acuticostata,* Lam.; *Lucina mutabilis,* Desh.; *Turritella desmaresti; Cypræa* sp.	8·5	metres.
2.	Clayey beds containing *Anisaster gibberulus*, Mich.; *Spondylus Aegyptiacus*, Newt.; *Pectunculus juxtadentatus*, Cossm.; *Cardita Fraasi,* n. sp. Opp.; *C. acuticostata*, Lam.; *Cytherea parisiensis*, Desh.; *Tellina reticulata*, Bell.; *Psammobia producta,* M.E. ...	4·0	„
3.	White limestone containing at the top *Echinolampas Crameri*, de Loriol; *E. globulus*, Laube; *Cardium* sp.; *Cytherea* sp.; *Turritella angulata*; while lower there occurs *Anisaster gibberulus*, Mich.; *Ostrea Clot-Beyi*, Bell.; *Lucina metableta*, Cossm.; *Turritella Desmaresti;* and *Dentalium* sp.	2·4	„
4.	Gypseous clays	4·5	„
5.	Yellow, unfossiliferous limestone	3·5	„
6.	Clay...	5·0	„
7.	Yellow limestone containing many internal casts of *Turritellæ*	3·7	„
8.	Gypseous Clays	4·5	„
9.	Hard yellow shelly limestone containing casts of *Ostrea Clot-Beyi*, Bell.	0·75	„
10.	Sandy clay to ground level	1·0	„
	TOTAL	37·85	metres.

The dip was 3° to 4° to the east; while at Ên Musa there was a sharp syncline with a sharp rise towards the cliff of El Amara.

At Wadi Dowaiaqa another section was measured on its north side:—

Top.	Porous yellow limestone containing numerous *Cardita acuticostata*, Lam.; *Cardium Schweinfurthi*, M. E.; *Cytherea parisiensis*, Desh.; *Turritella desmaresti*; *Cerithium* sp.; *Cassidaria nodosa*	8·0 metres.
2.	Greyish limestone containing *Anisaster gibberulus*, Mich.; *Vulsella crispata*, Fish.; *Carolia placunoides*, Cantr.; *Cardita acuticostata*, Lamp.; *C. Fraasi* n. sp. Opp.; *Cytherea parisiensis*, Desh.; *Tellina reticulata*, Bell.; *Plicatula polymorpha*; *Turritella cf. heluanensis*, M. E.	7·0 „
3.	Limestone containing similar fossils to No. 2, except that *Carolia* and *Vulsella* are absent	12·0 „
4.	Bluish clays	1·0 „
5.	Limestone in which occur *Spondylus Aegyptiacus*, Newt.; *Lucina mutabilis*, Cossm.; and *L.*, sp. to ground level	3·0 „
	TOTAL	31·0 metres.

The top bed has been quarried; the dip is 2° S.E. and 4° to 5° N.E. The beds in this section seem to represent fairly well all Schweinfurth's divisions of the Upper Moqattam. On examining the south side of the wadi, it was found that the top bed of this section formed the surface of the plateau of the Moqattam. It is also seen that the Oligocene rests on this bed as well as on bed No. 3. On the top of the Moqattam the remains of a geyser cone, or thermal spring tube are seen.

Examining these two sections of the Moqattam it is seen that, although the beds are different in their fossil contents and to some extent in lithological characters, the following correlation is fairly correct:—

EN MUSA SECTION		WADI DOWAIAQA
Bed 1	=	Bed 1
„ 2, 3	=	„ 2
„ 4, 5, 6	=	„ 3, 4
„ 7	=	„ 5

It is evident from these two sections, which contain similar fossils, that the thickness of Upper Moqattam beds does not exceed 40 metres.

It is true that the actual base of this series was not seen, but it could not be many metres below ground.

As the plateau of Gebel Moqattam is followed eastwards it gradually becomes lower and lower until it merges into the general level of the country; its surface being formed of Bed No. 1 (Ên Musa) bed of the Ên Musa Section. This bed on account of its superior hardness has resisted the denuding agents and thus given rise to the plateau.

At this point the following section of higher beds was seen :—

Top.	Marly limestone with friable limestone at top containing *Ostrea Clot-Beyi*, Bell.; *Isocardia* cf. *vorax*, n. sp. Oppenh.; and *Cardium Schweinfurthi*, M.E.	8·0 metres.
2.	Marly limestone containing plates of gypsum and *Ostrea Clot-Beyi*, Bell.; *O. Reili*; *Carolia placunoides*, Cantr.; *Turritella desmaresti*; *T. heluanensis*, M.E.; *Cerithium lamellosum*, Brug.; *Rimella duplicicosta*, Cossm.	8·0 „
3.	Greenish clays and a shelly limestone containing casts of *Turritella* and *Cerithia*	3·0 „
4.	Yellow, impure limestone containing (?) *Lithophagus* sp. at the base	3·0 „
	Total	22·0 metres.

Two kilometres to the S.E., higher beds were found in a breached dome. These are :—

Top.	Ferruginous sandy limestone	2·5 metres.
2.	Bluish clay	1·0 „
3.	Impure limestone containing at the top *Ostrea Clot-Beyi*, Bell.; *Isocardia* cf. *vorax*, Oppenh.; *Cardium Schweinfurthi*, M.E.; *Tellina reticulata*, Bell.; and at the base *Echinolampas Crameri*, de Loriol.	10·5 metres.
4.	Marls (with bed of gypsum in the middle containing *Ostrea Clot-Beyi*, Bell.); and *Carolia placunoides*, Cantr....	2·5 „
	Total	16·5 metres.

Collecting all the beds together from the two sections and correlating them into a general section, the following succession is obtained :—

Top.	Ferruginous sandy limestone	2·5	metres.
2.	Bluish clay	1·0	„
3.	Marly limestone friable at top and containing above, *Ostrea Clot-Beyi*, Bell. ; *Isocardia* cf. *vorax*, Oppenh. ; *Cardium Schweinfurthi*, M. E. ; *Tellina reticulata*, Bell. ; and at the base, *Echinolampas Crameri*, de Loriol ; *Anisaster gibberulus*, Mich.	10·5	„
4.	Yellow marly limestone containing *Anisaster gibberulus; Ostrea Clot-Beyi*, Bell.; *O. Reili; Carolia placunoides*, Cautr.; *Turritella desmaresti ; T. heluanensis*, M.E. ; *Cerithium duplicicosta*, Cossm. ; *C. lamellosum*, Brug.	1·0	„
5.	Marly limestone with plates of gypsum	7·0	„
6.	Limestone containing worn internal casts of *Spondylus Aegyptiacus; Turritella angulata; Mesalia Locardi*, Cossm.; and *Mesalia fasciata*, Lam.	0·5	„
7.	Greenish clays	2·5	„
8.	Impure, yellow limestone containing *Ostrea Clot-Beyi*, Bell.; *O. Reili; Carolia placunoides*,Cautr.; *Cardium Schweinfurthi*, M.E.; (?) *Lithophagus* sp. ... ... This lies on the Ên Musa bed.	3·0	„
	TOTAL	28·0	metres.

All these beds are overlaid by the Oligocene beds of the Petrified Forest ([1]) and only appear in the small domes produced at the nodes of the two folds which lie more or less at right angles to each other.

At the place known as Bir el Fahm ([2]) where the drainage from the Petrified Forest passes out into Wadi el Ti (Awagela) the corresponding fold was found forming the edge of the low cliff which is the southern boundary of that area of silicified wood. The dip is 8° to 10° SE. Here the highest beds hitherto seen were not present. By the side of the drainage line is the shaft sunk in 1845 by order of Mohammed Ali Pasha to find coal underneath. It was carried down 133 fathoms (243 metres) but the limestone was never passed, and it was then finally abandoned. ([3]) The shaft is known by the natives as the Bir el Fahm (the Coal-Shaft).

(1) See Section IV.
(2) See Section IV.
(3) "Egypt, the Soudan and Central Africa." 1861.

Further to the east, and nearer Gebel Amuna, there is a unique appearance in the geology where another small dome is breached. The beds are lying in the form of a basin on one side, the uppermost bed being Bed No. 3 of the foregoing section. Upon these beds lying horizontal in the basin are the following new beds :—

Top.	Sandy limestone	2·0	metres.
2.	Sands	12·0	„
3.	Ochreous, marly limestone containing *Turritella desmaresti* ; *T.* sp.	1·0	„
4.	Marls and clays containing much salt	11·0	„
	TOTAL...	26·0	metres.

There is here an apparent unconformity which has not been seen in any other part of the area.

Gebel Ansuri.—This hill is to the north of the previous place and 4 or 5 kilometres from the Old Post Road to Suez. In it the beds seen are higher in the series than any previously met with. This hill forms a breached dome with Gebel el Angobia as the eastern limb of the fold. In the former hill the dip is 10° in a north westerly direction, while further round towards the latter the dip is 15°, and in Gebel el Angobia itself it is 8° S.E. In the céntre of the dome which is formed at the surface by what is called the Ên Musa bed, the dip is 3° to 4° from the centre.

Section in Gebel Ansuri :—

Top.	Sandy limestones with marls at the base forming a sheer cliff	26	metres.
2.	Yellowish limestone with the bed of *Isocardia vorax*, Oppenh. at the top, and containing also *Turritella desmaresti*	12·0	„
3.	White limestone containing *Carolia* (?) *cymbulea*...	0·75	„
4.	White limestone containing *Ostrea Reili* and *O. Clot-Beyi*	3.25	„
5.	Yellowish limestone containing at the top *Rhabdocidaris Gaillardoti*, Gauth.; *Turritella angulata; T. desmaresti* ; *T.* sp. ; *Cerithium lamellosum* ; *Rimella duplicicosta* ; *Diastomum costellatum;* below, about 0·5 m. containing *Carolia* (?) *cymbulea* and *Plicatula polymorpha* ; while the rest of the rock is an oyster-bank composed of *Ostrea Clot-Beyi* ; *O. Reili* ; *O. Fraasi* and *Callianassa*	20·0	„
	TOTAL	62	metres.

These beds rested on the Ên Musa bed.

Gebel el Angobia.—In this hill the following section was obtained:

Top.	Hard limestone forming top of cliff but containing at its base casts of *Ostrea Clot-Beyi*	3·2	metres.
2.	Softer sandy limestone containing *Ostrea* sp. (casts); *Cardium* sp; *Plicatula polymorpha*; *Turritella* sp.; *T.* aff. *carinifera*; *T. angulata*; (?) *Pleurotoma*	10 0	„
3.	Harder yellow limestone	0·5	„
4.	Sandy and marly limestone...	14·0	„
5.	Hard yellow limestone	0 75	„
6.	Yellow sandy limestone	4·00	„
7.	Harder yellow limestone	1·0	„
8.	Softer „ „	4·25	„
9.	Harder „ „	0·50	„
10.	Softer „ „	8·00	„
11.	Harder „ „	0·30	„
12.	Softer yellow limestone containing *Mesalia fasciata*, Lam....	2·40	„
13.	White limestone containing *Carolia cymbulea*, Loc.	18·00	„
14.	Oyster limestone composed mainly of *Ostrea Fraasi*, M.E.; with a few *O. Clot-Beyi* ...	18·00	„
	TOTAL	84·90	metres.

From this section it is seen that there are at least 84 metres of beds younger than those in Gebel Moqattam, as all these beds overlie the Ên Musa bed.

The dome of El Angobia is bounded on all sides by a fault which has let down the Miocene against the Eocene. On the northwest side there is nearly always a small wedge of Oligocene between the Eocene and Miocene on the upthrow side of the fault. On the north side, part of the dome is cut off by an east and west fault. Along the northern edge the beds dip steeply towards the fault at an angle of 45°, but further on the dip is practically *nil*.

To the south of the thermal-spring cone on the north edge of El Angobia there occurs a small knoll of beds higher in the series than any hitherto met with. They consist of:—

Top.	Hard, sandy limestone containing *Ostrea* sp., and large gasteropod like *Tylostoma*	1·0 metre.
2.	Sandy beds	9·0 metres.
	TOTAL...	10·0 metres.

Basalt with Geyser plug standing out in relief near Wadi Gendali.

Bir Gendali.—Between the dome of El Angobia and the Eocene beds near Bir Gendali there occur a series of ridges of conglomerate which have been mapped as Lower Miocene. From beneath these the Oligocene comes up followed by the Eocene on the anticline corresponding to that of the above-mentioned dome. The dip of the beds is 8° N. Near Bir Gendali there is also a dip of 6° or 7° S.E. From the plateau near Bir Gendali the following fossils were collected from the beds in descending order :—

> Top. Grey limestone containing *Echinolampas Crameri,* de Loriol; *Ostrea Reili; O. Fraasi; Pecten Caillaudi,* Oppenh.; *Turritella angulata; T. desmaresti; Mesalia hofana,* M.E.; *Natica* (*Ampullina*) *Sigaretina,* Lamp.; *Solarium canaliculatum,* Lam.; *Cerithium lamellosum,* Brug.; *Clantithes goniophorus,* Bell.; *Ancilla Aegyptiaca,* Oppenh.

These rocks evidently represent the lowest beds of the El Angobia section and the Ên Musa bed.

Gebel Ali Hamum el Azraq.—This hill, which also bears the name of Gebel Amuna, has the highest beds of the series also present having a dip of 2° to 3° to the hill. This is to the west of Bir Gendali. From the representative of the top bed of the El Angobia section the following fossils were obtained, viz., *Spondylus Aegyptiacus,* Newt.; *Cardium obliquum,* Loc.; *Cytherea parisiensis.*

Wadi Gendali.—On either side of this wadi the Upper Moqattam beds persist for about 8 kilometres down the wadi. On the north they are covered by Oligocene beds, but between this and the wadi is a more or less level piece of ground with knolls of Eocene rock which is known by the name of El Kheshan. On the south the beds rise up in a terraced formation to the top of the plateau, the general dip being 3° or 4° N.W. which increases as the beds disappear under the Oligocene on the north side of the wadi.

About 8 kilometres down the wadi from Bir Gendali there are small tributary wadis which enter from both sides. In these occurs basalt together with the cones of thermal springs or geysers all resting on Upper Moqattam beds. Further examination of the wadi shows that it is formed by a trough-fault; the basalt and thermal-spring cones have been let down, and the fracture in one case passes through the middle of one of the cones. In this instance the hade of the fault is clearly seen and has an angle of between 70° and 80°. In fact, this valley conforms to the definition of a "Rift Valley." The Lower Moqattam beds are exposed in both cliffs; while on the west they are covered on the plateau by the Upper Moqattam, on the east the latter only occur as outliers. The throw of the fault is estimated to be 165 metres.

It would seem as though the first indication of the unconformity between the Upper and Lower Moqattam is given here; the beds below the Ên Musa bed were not noticed, only the large oyster beds which occur above it being noted.

Gebel Gafra.—The next place where the Upper Moqattam is met with is in Gebel Gafra on the edge of the plain separating the Nile Delta from the hills. This hill is in the form of a flat dome, and it is in the centre of it that these beds show up through the Oligocene. On the south side of this hill the Miocene is thrown down against the Eocene by a fault, while on the north the latter beds dip under the Oligocene at an angle of 3°. Here there are 4 to 6 metres of deposits above the Carolia beds.

To the east the Eocene beds disappear under the Oligocene and Miocene beds. They are seen to form the walls of the throat of a volcano (1) on the east flank of Gebel Gafra where the limestone has been altered by the heat and thermal waters into a "Clinkstone" which is as brittle as glass.

Eocene limestone is also seen forming the side of an old volcanic cone 11·5 kilometres east of Der el Beda. Here it contains casts of *Ostrea Clot-Beyi.*

Gebel Shabrawet.—The next place where Upper Moqattam beds are met with is at and around Gebel Shabrawet. On the north-east side of this hill the Upper Moqattam has been let down against the Cretaceous by a fault, or to speak more correctly, a series of faults. There are 28 metres of calcareous sandy beds visible. To the north-west of this hill the Upper Moqattam appears between two ridges of Miocene. The lower ridge of the latter is the result of a fault of 25 metres throwing down to the north, thus exposing the Eocene by the cutting back of the upper escarpment. The narrow band of Eocene is really an anticline which has been fractured by the fault and extends as far as El Gherbe where it disappears under the younger deposits. The beds seen are those containing *Ostrea Clot-Beyi* with *Carolia* in the beds below, being in all 19 metres thick.

To the south of Gebel Shabrawet and separated from it by a wadi is a plateau of limestone 115 metres high. It is composed mainly of Lower Moqattam beds, but is capped in nearly every place by Upper Moqat-

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(1) See Section III.

tam and Oligocene. The *Carolia* bed is the representative at first, but farther south this is capped by the *Ostrea Clot-Beyi* bed.

West from the edge of the cliff there is a fault, along which a drainage has formed, which lets down the Upper Moqattam about 100 metres. The line of fault passes along the side of a fissure plugged with quartzite. A second fault takes place a little further west, but it dies out to the northwest.

Nearer Gebel Genefe there seem to be three step-faults which have let down the beds successively to the east, each being marked by a thin covering of Oligocene on the downthrow side. At the foot of Gebel Genefe the most westerly fault bends round and cuts off the others continuing itself along the foot of that hill and joining the main fault which has let down the Miocene against the foot of the Genefe escarpment.

It may be said in a general way that the Upper Moqattam beds nearly always cover the Lower Moqattam beds in the plateau between Gebel Shabrawet and Gebel Genefe. There is, however, a well marked unconformity between the two.

Gebel Genefe.—In this hill, which is almost entirely composed of Lower Moqattam beds, the Upper beds only occur as a thin coating some distance from the highest point of the ridge. Here only the *Ostrea Clot-Beyi* beds are seen overlapping the eroded Lower Moqattam beds.[1] For some distance the covering of Upper Moqattam beds is so thin that the Lower beds crop up now and then through them. The proof of unconformity and overlap is overwhelming, for first of all the Lower beds are dipping at 5° or 6° while the Upper beds lie horizontal; secondly, the latter do not lie on the uppermost beds of the former; and thirdly, if the higher beds of the Upper be produced they would probably be nearly on a level with the uppermost of the Lower Moqattam. As far as seen, there are at least 37 metres of Upper Moqattam beds missing at this place.

Between Gebel Genefe and Gebel Awebed the Eocene beds have evidently been thrown into a series of folds, and the Upper Moqattam appears in more or less elliptical exposures through the Oligocene suggesting the nodes of interference between the two sets of folds. In those exposures additional proof of the unconformity between the Upper and Lower beds is forthcoming in the behaviour of the *Ostrea Clot-Beyi* bed. In these the lowest bed seen is a white limestone with a very irregular surface. On this the *Ostrea Clot-Beyi* bed lies; in places it has almost thinned out to nothing, while a little further on it

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(1) See Section I.

thickens considerably. The thickness of Upper Moqattam beds seen here does not exceed 30 metres.

On the south side of Gebel Genefe these beds form a fringe under which the Lower Moqattam beds disappear, the former in turn going under the Oligocene and Miocene to reappear again at the foot of Gebel Ataqa.

Gebel Awebed.—At the west end of this hill of Lower Moqattam which stands up in a splendid isolation in the midst of the Newer Tertiaries, the Upper Moqattam is let down by a V-shaped fault against the Lower beds. The unconformity is again confirmed by the difference in dip of the two series. The beds dip 8° to the west and soon disappear under the Oligocene, and they have been let down 50 metres to the north by one of the legs of the "V." In this area further to the west the faulting exhibits some interesting points.(1) The Miocene and Upper Moqattam have been broken over the ridge of Lower Moqattam, one half of which has also sunk beneath the overlying beds. A point of interest is the evidence of the tearing and pulling over to the downthrow side of the fault of the Upper beds, which are seen resting at an angle of 35° against the broken ends of the Lower Moqattam beds.

On the south side of this ridge there are 20 to 30 metres of Upper Moqattam beds dipping at 6° to the south; these pass under the plain to the south and reappear once more at the foot of Gebel Um Thibua and Gebel Ataqa. Further west the Upper beds gradually overtop the Lower until the latter disappear, the former by a decrease of dip disappearing in turn under the Oligocene.

Along the south of Gebel Awebed (2) Upper Moqattam beds are seen standing up at a steep angle, having been pulled over by the fault which runs along the foot of the hill.

Gebel Um Thibua and Gebel Ataqa.—Patches of Upper Moqattam beds occur near the foot of Gebel Um Thibua (2) where they have evidently been faulted down. They also occur as inliers in the younger rocks, and outliers on the western flank of Gebel Ataqa. Further to the east along the foot of the escarpment of Gebel Ataqa the Upper Moqattam comes up on a fold and is surrounded by the Oligocene, while still farther on and connected with this exposure is another area of these beds with a dip of 15° to the N.W. Under these the Lower beds appear. It is evident that these have been faulted down from the main plateau of Ataqa. The Upper Moqattam underlies the detritus-covered plain

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(1) See Section V.
(2) See Section II.

View of Gebel Ataqa showing Eocene limestone faulted against the Cretaceous.
(The low hills in front of the Cretaceous cliff are Eocene).

to the east of the latter exposure and appears on the west flank of the lower plateau which lies at the foot of Gebel Ataqa. This is the last exposure noted in this area.

It is now possible to give a general section of the Upper Moqattam in this area for the purpose of comparison with its occurrences in other localities:—

Top.	Hard sandy limestone containing *Ostrea* sp.: and a gasteropod like *Tylostoma*	1·0 metre.
2.	Sandy beds	9·0 metres.
3.	Hard limestone containing at its base casts of *Ostrea Clot-Beyi*; *Spondylus Aegyptiacus*; *Cardium obliquum*; *Cytherea parisiensis* ...	3·2 "
4.	Softer sandy limestone containing casts of *Ostrea* sp.; *Cardium* sp.; *Plicatula polymorpha*; *Turritella angulata*; *T.* aff. *carinifera*; *T.* sp.; (?) *Pleurotoma* sp.	10·0 "
5.	Hard band of yellow limestone	0·5 "
6.	Sandy, marly limestone.	14·0 "
7.	Hard band of yellow limestone	0·75 "
8.	Yellow, sandy limestone.	4·0 "
9.	Hard band of yellow limestone	1·0 "
10.	Softer yellow limestone.	4·25 "
11.	Hard band of yellow limestone	0·50 "
12.	Softer yellow limestone.	8·00 "
13.	Hard band of yellow limestone	0·30 "
14.	Softer yellow limestone containing *Mesalia fasciata*	2·40 "
15.	Whitish limestone containing *Echinolampas Crameri*; *Ostrea Reili*; *O. Clot-Beyi*; *O. Fraasi*; *Pecten Caillaudi*; *Carolia cymbulea*; *C. placunoides*; *Isocardia vorax*; *Isocardia* cf. *vorax*; *Cardium Schweinfurthi*; *Tellina reticulata*; *Turritella angulata*; *T. desmaresti*; *T. heluanensis*; *Cerithium duplicicosta*; *C. lamellosum*	18·00 "
16.	Yellowish limestone containing *Rhabdocidaris Gaillardoti*; *Anisaster gibberulus*; *Ostrea Fraasi*; *O. Reili*; *O. Clot-Beyi*; *Spondylus Aegyptiacus*; *Carolia cymbulea*; *Plicatula polymorpha*; *Cardium Schweinfurthi*; *Corbula Chmeietensis*; *Turritella angulata*; *T. desmaresti*; *T.* sp.; *Mesalia fasciata*; *M. hofana*; *M. Locardi*; *Natica* (*Ampullina*) *sigaretina*; *Solarium canaliculatum*; *Cerithium duplicicosta*; *C. lamellosum*; *Rimella duplicicosta*; *Diastomum costellatum*; *Clanlithes goniophorus*; *Ancilla Aegyptiaca*; and *Callianassa* sp.	18·00 "

17.	Ên Musa Bed, yellowish limestone (dolomitic in places) containing *Echinolampas Crameri*; *Anisaster gibberulus*; *Pecten Caillaudi*; *Spondylus Aegyptiacus*; *Cardita acuticostata*; *Lucina mutabilis*; *Cardium Schweinfurthi*; *Cytherea parisiensis*; *Turritella desmaresti*; *Cerithium* sp.; *Cassidaria nodosa*; *Cypraea* sp.	8·50 metres
18.	Clayey beds containing *Anisaster gibberulus*; *Spondylus Aegyptiacus*; *Pectunculus juxtadentatus*; *Cardita acuticostata*; *C. Fraasi*; *Cytherea Parisiensis*; *Tellina reticulata*; *Psammobia producta*.	4·00 „
19.	White limestone containing *Echinolampas Crameri*; *E. globulus*; *Anisaster gibberulus*; *Vulsella crispata*; *Carolia placunoides*; *Cardita acuticostata*; *C. Fraasi*; *Cardium* sp.; *Cytherea parisiensis*; *Plicatula polymorpha*; *Tellina reticulata*; *Turritella angulata*; *T.* cf. *heluanensis*; *Dentalium* sp.	2·40 „
20.	Gypseous clays	4·50 „
21.	Yellow limestone containing similar fossils to Bed N° 19, except that *Carolia* and *Vulsella* are absent...	3·50 „
22.	Clay...	5·00 „
23.	Yellow limestone containing many *Spondylus Aegyptiacus*; *Lucina mutabilis*; and internal casts of *Turritella*	3·70 „
24.	Gypseous clays.	4·50 „
55.	Hard, yellow, shelly limestone containing casts of *Ostrea Clot-Beyi*.	0·75 „
26.	Sandy clay to ground level...	1·00 „
	TOTAL...	132·75 metres.

In discussing the divisions of the Upper Moqattam by the various workers, the work has been very much simplified by the admirable table quoted from Dr. Blanckenhorn's paper. In it the subdivisions of Schweinfurth, Mayer-Eymar and Sickenberger are correlated with those of that author. It only remains, therefore, to compare the sections of the present writer with those of Dr. Blanckenhorn. It is difficult to compare them with the general section quoted, by taking the actual section measured on Gebel Moqattam (1) and comparing it

(1) Sitzungsb. d. Math-phys. Classe d. kgl. bayer-Akad. d. Wissensch. Bd. XXXII, 1902, Hft. III. S. 370-371-372.

with that measured by the author near Ên Musa, the following correlation represents the relations of the sections to each other:—

Blanckenhorn Section		Barron Section
Bed No. 8	=	Bed No. 1
" " 7	=	" " 2
" " 5, 4	=	" " 4
" " 3	=	" " 5
" " 2	=	" " 6, 7
" " 1	=	" " 8, 9, 10
" " 6	=	" " 3
Thickness 37·40 m.		37·85 m.

When, however, a comparison comes to be made between the general section of the Author and that of Dr. Blanckenhorn already quoted, it is found that there are 70 metres of beds occurring in the former section which are not present in the latter as they are above its uppermost bed in point of succession. The question arises, to what stage of the Eocene are these beds to be assigned? Are they Upper Moqattam (Middle Eocene) or Bartonian (Upper Eocene)?

A search through all the previous literature on the Eocene of Egypt does not help to answer the question at all, as no beds higher than the limestone containing *Echinolampas Crameri* occurring in Gebel Moqattam appear to be known. It therefore remains for the author to state that if fossil evidence be taken as a criterion they are undoubtedly of Upper Moqattam age. If the general section of the Author be examined it will be seen that there are 36 metres of limestone above the Ên Musa bed (Top bed of all the previous authors), which contain exactly similar fossils to those occurring in that bed. Again, almost at the top of the series, occurs a bed containing *Plicatula polymorpha*, *Turritella angulata*, and *T.* aff. *carinifera*, which seems to settle the Upper Moqattam age of the whole series.

On examining the sections measured by Dr. Blanckenhorn in the Fayum, a fresh difficulty presents itself when one attempts a comparison between the beds in that area and those in the Cairo-Suez district. There one sees, according to that observer's sections, (1) that while the

(1) Loc. cit. p. 382. "Profile of Gebel Achdar."

uppermost bed *(Echinolampas Crameri bed)* is only 1 to 1·5 m. thick-much thinner than in the Gebel Moqattam—the underlying beds are very considerably thickened the total being two to three times greater. Overlying the *Echinolampas Crameri* bed comes a great thickness of loose or only partly consolidated sands containing numerous Mammalian remains which are classed as Bartonian or Upper Eocene. These are estuarine or brackish water and were apparently deposited quite close to the shore of that period. In the description of the various sections no mention is made of any discordance or break in the sedimentation of the series, but it is stated that the *Echinolampas Crameri* bed is the direct downward continuation of these brackish water sands. This is the question which awaits an answer. How is it that, while the lower beds of this section have all the characters common to those in the Gebel Moqattam section immediately above the *Echinolampas Crameri* bed, there is an abrupt change from marine limestone of Middle Eocene age to loose or partly consolidated sands (estuarine) of Bartonian age with a large mammalian fauna, while in the Cairo-Suez district there are 40 metres of limestone above the bed in question, with about 30 metres more of sandy, impure limestone above these ? These 70 metres of beds are undoubtedly of Upper Moqattam age by their fossils ; while the lithological characters of the upper beds indicate a shallower sea and closer proximity to land, thus suggesting a gradual passage from true marine to the estuarine or brackish water beds found in the Fayum. If, then, these beds are part of the true marine Upper Moqattam series, what has become of their homotaxial equivalents in the Fayum sections ? It seems as though there is only one explanation possible, viz., that the representatives of these beds are absent in the Fayum, and have been removed by denudation, the junction between the Upper and Middle Eocene thus marking an unconformity and break in the sedimentation. It would be idle to deny the Upper Moqattam age of the Cairo-Suez beds in the face of the overwhelming fossil evidence for this determination and it would seem that, from whatever point of view the question is examined, one is driven to the conclusion that the continental period noted at the close of the Upper Moqattam stage in the Cairo-Suez district, extended also into the Fayum.

In the recently issued Report on the Fayum (1) by Mr. Beadnell, the same view is set forth as to the boundaries of the Upper Moqattam and its relation to the overlying beds. Mr. Beadnell states (p. 49) that his Qasr el Sagha series is the equivalent of the Upper Moqattam beds

(1) "Topography and Geology of the Fayum Province of Egypt." Survey Dept. Cairo, 1905.

of Gebel Moqattam near Cairo. In discussing the relationship between these and the overlying beds he says (p.55):—"From an examination of " the series in the field, there is no doubt that, in at least the centre " of the area, the deposition of the lowest beds (of the Upper Eocene) " was continuous with those of the Qasr el Sagha (Middle Eocene) " series below. Followed away from the centre (i. e.,the district round " Widan el Faras, the eastern extremity of Gebel el Qatrani) the " series gradually thins out, and eastwards, at Elwat Hialla, some 23 " kilometres north of Tamia, has a thickness of only 40 metres, the " basal beds being apparently laid on to a bed of limestone of the Qasr " el Sagha series about the horizon of Bed 12 in section XXIII (this " is 68 metres below the uppermost bed of the Section). The junction " here is apparently one of perfect conformity as far as the individual " beds go, and the peculiar sequence does not seem to be due to " ordinary overlap; it appears as if the change from marine to estuar- " ine conditions had set in earlier here than further to the west, with " the result that the upper Qasr el Sagha beds are wanting. Moreover, " the accumulation of estuarine beds went on so slowly in this locality " that the series does not attain to nearly its normal thickness, while " further east it dies out altogether."

In considering the above statement, the same difficulty is met as in the case of Blanckenhorn's section. The beds in the Moqattam and the Qasr el Sagha Sections are identical, but in the latter case, above the limestone containing *Echinolampas Crameri*, the resemblance to the Upper Moqattam beds of the Cairo-Suez district ceases. In the latter district there are over 40 metres of limestone containing the above mentioned echinoderm, and over 30 metres more of sandier limestone also marked by Upper Moqattam fossils. How comes this sudden discrepancy ? Where are the representatives of these 70 metres of beds in the Fayum ? There is no doubt that the Fayum was nearer the land in Eocene times than the district east of Cairo, as is shown by the greater thickness of the homotaxial beds in the former place as compared with the latter; but the general characters of the beds are the same, limestone bed corresponding to limestone, and sandier or marly beds to similar ones in the other section.

In the Fayum section when it is followed up into the Upper Eocene, the following significant fact comes to light, viz., that above the white limestone at the top of the Middle Eocene there come soft, loosely-compacted sands and sandstone. This is a sudden and radical change of conditions, and is strongly suggestive of a hiatus in the sedimentation.

This suggestion is further supported by the statement that the estuarine beds of the Upper Eocene do not lie on the same bed all over the area, but their basal bed lies on beds 68 metres apart in the vertical sequence, while the horizontal distance apart is 23 kilometres. The explanation given to account for this apparent discordance, viz., that estuarine conditions had set in earlier in this area and therefore the upper Qasr el Sagha beds are wanting, leaves one in a difficulty, for if it be accepted then these beds cannot be of Upper Eocene age, but are homotaxial with the Middle Eocene beds of which they are the estuarine representatives. If they are of Upper Eocene age as Mr. Beadnell states, then there is a break in the sedimentation represented by the absence of the 68 metres above-mentioned. This is the more probable explanation, and if it be granted that the 70 metres, known to exist in the Cairo-Suez district above the representative of the uppermost bed of the Middle Eocene in the Fayum, have been removed by denudation prior to the deposition of the Upper Eocene estuarine beds, then the abrupt change in the character of the beds becomes easily understood.

The fact that the highest members of the Middle Eocene occur in the middle of the Cairo-Suez area with the lower members on either side of them, argues the presence of a trough with corresponding anticlines to east and west of it. The easterly ridge is represented by the area round Gebel Genefe, while the westerly member is Gebel Moqattam and the district including the Fayum.

There seems to be only one explanation possible to account for the presence of these beds in the Cairo-Suez area, and their absence in the Fayum, viz., that the Fayum was a land-surface shortly after the deposition of the *Echinolampas Crameri* bed, this bed and those above it underwent denudation until the land again sank under the sea, when the Upper Eocene estuarine beds were deposited.

Unconformity between Upper and Lower Moqattam:—

This, as far as the author knows, is the first occurrence of this kind noted in Egypt. The first indication of it was seen at the wadi formed by a trough-fault about 9 kilometres E.N.E. from Bir Gendali. Here the Ên Musa bed was not seen nor any of the beds under it, only those overlying it being recognised. In the next exposure to the north and south of Gebel Shabrawet the same was seen, only a small thickness of beds above the Ên Musa bed being present in any one place. A difference in dip between the two divisions of the Moqattam proves the discordance between them; while the evidence for overlap seen in Gebel Genefe is also conclusive.

When the conditions which brought about this state of things are considered some very interesting points come to light. It has been shown in a paper on the Miocene by the author that at the beginning of that period the land to the east of the Nile Valley was above water (1), while Gebel Moqattam was almost certainly part of the land surface also. It seems that after the deposition of the fossiliferous Lower Miocene in the troughs formed by the folds set up by the earth movements during Oligocene times, a depression set in in the neighbourhood of what is now the Isthmus of Suez in which deeper-water beds of the Middle Miocene were deposited, while on the west in the vicinity of Gebel Moqattam only shallow-water representatives are present. In fact, as will be seen, Gebel Moqattam remained more or less stationary amid the up-and-down movement around it.

Coming down to Oligocene times, the evidence goes to show that during this period also, Gebel Moqattam reared its head above the waters of the earlier Oligocene sea. The fact that to the east of this hill the Oligocene sands and gravels overlie beds about 70 metres higher in the series than those present in this hill, goes to prove that it formed part of a ridge forming dry land while the Oligocene was being laid down in the trough to the east in which the higher Upper Moqattam beds were submerged. The denudation of Gebel Moqattam must have proceeded parallel with the deposition of the Oligocene in this place, while later on that hill was depressed sufficiently to allow of its being covered by the Oligocene waters as is shown by the remains of beds round the cone of the old Geyser on the top of that plateau. This did not, however, take place until the 70 metres of beds known to be present on this side of the Nile Valley had been removed by denudation. There are thus good grounds for assuming that the Oligocene beds in different parts of that area are not homotaxial, but may probably range from Lower to perhaps Upper Oligocene. One thing is certain, that the Gebel Ahmar beds on the flanks of the Moqattam hill are much higher in the series than those to the east.

Passing on to the consideration of the conditions which obtained during Upper Moqattam times in this area, it is found that the part which is now Gebel Moqattam played quite a different rôle; for instead of being the high land or anticline, it was apparently on the lowest part of a syncline. The author has not had an opportunity, since

(1) Geol. Mag; No. 486, 1904, p. 604 and 607.

mapping the area under description, of examining the relations between the Upper and Lower Moqattam in Gebel Moqattam, but as stated at the beginning of this section on the discordance between the two divisions of the Moqattam, no unconformity has been described by previous observers. It may be assumed, therefore, until subsequent investigation may perhaps prove it to be wrong, that the sedimentation was unbroken from the Lower Moqattam upwards. It is, however, only right to state that the very abrupt change from white limestone to impure marly limestones and clays which can be noticed at a distance by even a casual observer, suggests to the author's mind the probability of the existence of the unconformity even in the Moqattam itself. Taking the above assumption to be correct in the meantime, the land on the line of the Nile Valley was under the Eocene sea, while that to the east formed dry land, and underwent denudation during the time that the beds from the base up to and above the top of the Ên Musa bed were being deposited. During the deposition of the latter bed a downward movement set in from west to east; the Lower Moqattam with its uneven surface gradually sank beneath the waves; and the oyster banks and shallow-water limestones of the Upper Moqattam were deposited.

Reasoning from the evidence adduced in the preceding pages, it would seem as if the ground represented by the Fayum and Gebel Moqattam had been raised above the sea by the concomitant upward movement corresponding to the depression mentioned, and the beds overlying the Ên Musa bed were removed by the denuding agents.

Lower Moqattam.

Beds of this age were first met with in the faulted wadi about 8 kilometres E.N.E. of Bir Gendali. These form the sides of the valley while the Upper Moqattam covered them to the west; on the east they form the entire plateau of Gebels Qatamia, Um Thibua, and Ataqa. As far as could be seen from the sheer cliff in which they occurred, these beds were composed of white and grey limestones which contained at the base *Echinolampas Crameri* and *Schizaster* sp.

Near Gebel Shabrawet.—To the south of this hill the plateau on the opposite side of the drainage line is composed (except for a thin cap of Upper Moqattam) of Lower Moqattam beds. As mentioned in the earlier part of this chapter, this plateau is broken by a series of step-faults which let down the beds to the east. In the plateau the beds dip gently at 3° S., while there is a steeper dip of 5° or 6° to the

S.E., towards the drainage which passes out in that direction. In all there are about 115 metres of beds above ground, of which the lower third is masked by sand; the middle third is composed of hard yellow, purple, and reddish limestones; while the upper part is mainly yellow limestone. Near the base of the latter is a bed of grit 0·5 metres thick full of the shells of a large oyster—*Ostrea roucana.* In the middle part there is a yellow marly bed remarkable for the way it is seamed and veined by gypsum. These seams run along joint planes as well as parallel with the bedding, and some of them of a fibrous variety are 7 centimetres thick.

Gebel Genefe.—Following these beds southwards it is found that one of the faults previously mentioned has bent round to the S.E., thus causing a fracture and displacement of the beds along the north foot of Gebel Genefe. The main mass of this hill is composed of Lower Moqattam beds, a thin cap of Upper Moqattam lying discordantly to the west. (1) The fault above-mentioned, if followed up, is found to bend round to the south and join the main line of fault by which the Miocene beds are thrown down against the foot of the cliff. (2) Part of the Lower Moqattam beds are also seen to be let down from the top of the cliff. The main mass of Genefe cliff is composed of white limestones poor in fossils; but near the top there occurs a bed containing a small echinid *Sismondia Saemanni*, Desh. and *Gissortia gigantea;* and forming the uppermost bed a limestone full of *Goniaraea elegans*, Seym. sp. and *Dendracis conferta*, Felix. The dip at the edge of the cliff is almost *nil*, but on the northwest side near the fault it is 5° to 6° as it disappears under the Upper Moqattam. From this point the beds dip from a centre as in a dome.

Alabaster Bed.—About 10 metres from the base of the cliff there is a bed of alabaster from 0·5 to 1 metre thick. A company was formed many years ago to work this mineral, but apparently it was not a success, as it was abandoned. The mineral as far as seen was very irregular in quality nearly all of it being dark, inclined to be patchy, and containing blemishes. In the limited exposure seen, the vein did not seem to be at all constant.

Further south the beds are brought down by a fold against the Miocene beds, and in this bend there occur some Upper Moqattam and one or two plugged throats of thermal springs. Two kilometres further on they go under the Upper Moqattam beds and disappear, coming up once more in Gebel Ataqa.

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(1) See Section I.
(2) See Section I.

Gebel Awebed.—This hill is called by German geologists a "horst." It is the representative of what was probably a big fold in the Eocene in the troughs of which the Miocene was deposited. It may be that it was under the Miocene sea as Gebel Genefe undoubtedly was. Of this however there is no conclusive evidence, although what there is rather favours this view. Be that as it may, the evidence as to the faulting which has circumscribed this hill being Post-Miocene is indubitable, and it is to this cause that it owes its present unique and commanding position. On examination it is found that Awebed (1) is the remains of an anticline from which the two corresponding synclines have been cut off by a double fault. The dips confirm this, being respectively 8° to N. and S. from the middle line.

At the top of the hill is the bed containing *Astrocaenia ægyptiaca*, Felix; *Goniaraea* sp.; *Stylophora* sp.; and *Dendracis conferta*, while at the base of this bed occurs *Echinolampas Crameri.* The thickness of the strata in this hill is 180 metres, and may possibly be 200 metres. In the upper beds there is much variation of colour due to manganese, many of the beds being variegated in a wonderful manner. On the edges of the hill some of the beds, especially the Upper Moqattam, have been pulled over by the drag of the fault and made to assume an almost vertical position, but the majority of the beds have the normal dip mentioned above.

At the edge of the Eocene is a curious altered rock which looks like a gritty limestone and is coloured by ferric oxide in an irregular manner. In places it has veins of dark siliceous sinter in it. It is thus probably a limestone which has been altered by the hot silicated waters which issued from the fissure near by.

Caves.—In this hill are some caves which occur on its south side. These are formed along the bedding plane between a hard grey limestone and a more porous purple one. They are undoubtedly "Solution Caves," and owe their origin to the percolating water which made its way down the cracks and along the bedding plane. The caves are of different sizes, from those which will only admit a man's fist to one which allows a man sitting upright. They gradually narrow as they penetrate the hill. On the floor of the largest, stalagmite was found, and this cave has also been a hyena's den at one time as shown by the number of bones lying about in it.

Further west the Miocene is seen faulted down against a cliff of Lower Moqattam, the latter showing beautiful examples of "cirque" formation.

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(1) See Section II.

Gebel Um Thibua.—This hill is entirely composed of Lower Moqattam beds having a dip near the top of 8°, while at the base it is 15° S. Dolerite is intrusive at the eastern foot of the hill, and apparently rises up a vertical fissure, but before reaching the surface it has penetrated between the beds producing alteration on both sides. The *Dendracis* bed overlies the dolerite and an *Operculina* bed has also undergone alteration. It is possible that the beds on either side of the small wadi which separates this hill from Gebel Ataqa are part of a fold.

On the north side of this hill is a small ridge (1) which has been let down by the main fault which bounds the north foot of Gebel Ataqa.

Gebel Ataqa.—The whole of this range on its western end is composed of Lower Moqattam except some few outliers of Upper Moqattam beds. It gradually rises from ground-level to its highest point near the sea, where Cretaceous beds bulk largely in the escarpment. Along its north foot are some outliers of Upper and Lower Moqattam beds which have been faulted down from the main cliff. In one of them there is a dip of 15° away from the cliff, thus showing that it is the remains of the south limb of a syncline which has been broken. The cliff behind this place did not prove to be very fossiliferous. At the top were found beds higher in the series than hitherto. These contained many *Lucinae* and spirals of a large *Cerithium* (?) *giganteum*. Under these came the beds with *Dendracis conferta*, and the remainder of the cliff was formed of hard grey limestones.

In the plateau faulted down at the foot of the main hill of Gebel Ataqa, the uppermost bed contained *Dictyoconus coralloides*; *Dendracis conferta*; *Sismondia Saemanni*, and other echinid spines, as well as oolitic grains. This bed is to all intents and purposes a coral reef. Below this came the bed with *Gissortia gigantea*. The dip here was 7° towards the cliff. On the fault-line the beds are shattered for several metres beyond the actual plane of movement.

In the hill on the upthrow side of the fault and forming a prominent angle on the main plateau the uppermost bed is the *Gissortia* bed. Below this comes a series of soft, chalky limestones containing crabs' claws and badly preserved Nummulites like *N. gizehensis*, as well as a smaller variety. The total thickness of beds in this hill is 270 metres as measured by aneroid. The throw of the fault at this point is thus 270 metres. There is also a secondary fault in this hill having a 70-metres throw.

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(1) See Section II

Lower Moqattam beds cover the whole of Gebel Ataqa and are underlaid by the Upper Cretaceous beds. In the neighbourhood of the quarry which was opened by the Suez Canal Co., there is a ridge of Lower Moqattam which has been let down by the main fault. A drainage separates it from the main cliff. The lower part of the main cliff is Cretaceous, at the top of which comes a bed of gypsum which has also been worked by the Suez Canal Co. Above this the beds are all Eocene and are marked by casts of *Nummulites* (?) *gizehensis*, while at the top comes a bed of that foraminifer and the *Dendracis conferta* bed containing *Dictyoconus coralloides; Echinocyamus Luciana*, de Lor.; and *Sismondia Saemanni*. The dip here was 5° away from the cliff, and this soon caused the Cretaceous to run underground.

In the faulted footridge the gypseous bed was just visible at the base, and as the thickness of the beds here was 155 metres, it follows that there are beds of that thickness in the cliff. Further south the fault cuts into the cliff and lets down part of it. The Moqattam forms a cap on the upthrow and downthrow sides of the fault, while on the extreme end of the cliff this rock is seen to form small outliers on the Cretaceous.

View of Gebel Shabrawet showing the tilted strata of the Cretaceous.

CHAPTER VI.

CRETACEOUS.

In the area under description, beds of this age are only known from two localities, viz., Gebel Shabrawet, and Gebel Ataqa. In the former place they occur as inliers standing up in the midst of Eocene, Oligocene, Miocene, and Pleistocene beds; while in the latter they occur in their normal position in the cliff below the Eocene.

Gebel Shabrawet:—Taking the occurrence at Shabrawet as the first in order of description, the following is a detailed account of it. Travelling on the railway between Ismailia and Suez, one cannot help noticing a dark-brown hill which rears its crest above the level of the surrounding plateau and is composed of highly-tilted beds. This is Gebel Shabrawet. A closer acquaintance shows that it is composed of Cretaceous rocks, much twisted and bent, and showing evidence of having undergone considerable stress from earth-movements. Approaching it from the east, it is found that one passes from Recent or Pleistocene deposits on to Oligocene beds containing fossil wood and plugged-up thermal water fissures, succeeded by Eocene rocks again capped by Oligocene. These are found in their present position as the result of a series of faults which has let down the whole against the Cretaceous, at the same time fracturing the series and causing the reduplication of the outcrop mentioned. After examining the hill at one or two points, it was concluded that the best place to examine a section was to work from the northeast side towards the crest, as the whole series was better exposed for purposes of measurement on this line. The following is a detailed section of the hill. For the general appearance of the hill on the line of section see Section VII.

Top.	Hard limestone, weathering blue	8·8	metres.
2.	White limestone...	19·5	„
3.	Softer, yellow, marly beds	9·3	„
4.	Hard, splintery limestone...	3·1	„
5.	Soft, yellow, sandy limestone with *Ostrea* sp.; and gasteropoda	7·1	„
6.	Sandy white limestone containing large *Nautili*, etc.	3·1	„
7.	Hard, siliceous, splintery limestone...	5·3	„

8.	White limestone	10·6	metres
9.	Hard white limestone	1·7	,,
10.	White limestone with flints	36·5	,,
11.	Hard, yellowish limestone...	14·2	,,
12.	White limestone	25·7	,,
13.	Greenish marls containing *Ostrea flabellata; O. mermeti; O. olisiponensis; Cardium* sp.	19·0	,,
14.	White limestone full of *Ostrea mermeti*	3·0	,,
15.	do. do. do.	33·0	,,
16.	Hard, white, sandy limestone	6·0	,,
17.	Hard, white, marly limestone	4·0	,,
18.	White, marly limestone	15·0	,,
19.	Harder, white, marly limestone with *Ostrea flabellata*	10·0	,,
20.	Hard, sandy, marly beds	3·4	,,
21.	Sandy, marly beds with casts of *Ostrea mermeti; O. flabellata;* etc.	2·2	,,
22.	Softer marly beds with harder layers, containing *Ostrea mermeti; O. flabellata; O. olisiponensis; Hemiaster* sp.; and gasteropoda	6·7	,,
23.	Hard, marly limestone containing in the last metre, *Ostrea mermeti*...	9·2	,,
24.	Marly limestone containing *Ostrea flabellata; O. mermeti;* and *O. olisiponensis*	4·2	,,
25.	Hard, white limestone	6·0	,,
26.	Hard, grey limestone	0·5	,,
27.	White marly limestone	3·7	,,
28.	Hard grey limestone with small (?) foraminifera	4·0	,,
29.	Marly beds containing fibrous gypsum and *Ostrea flabellata*	11·5	,,
30.	Soft, white limestone...	4·9	,,
31.	Hard, marly limestone	3·6	,,
32.	,, ,, ,, ...	4·5	,,
33.	,, ,, with fibrous gypsum...	5·9	,,
34.	Marly limestone (dip 70° towards N.)	8·3	,,
35.	Greenish marls containing gypsum, small ostrea, gasteropoda, and pelecypoda	8·9	,,
36.	Marly beds containing *Hemiaster* sp. and a large *Conus*	6·3	,,
37.	Marly limestone	5·3	,,
38.	Softer sandy beds	1·6	,,
39.	Sandy beds	4·4	,,
40.	Marly limestone	2·5	,,
41.	Marly beds	1·3	,,
42.	Much-crushed limestone	3·4	,,
43.	Marly beds with a gritty bed at the top 0·3 m. thick containing echinid spines...	14·0	,,
44.	Marly limestone	5·8	,,

45.	Hard, yellow limestone	4·2	„
46.	Greenish gypseous marls containing *Ostrea flabellata;* and an echinid in the upper layer...	16·0	„
47.	Yellowish limestone containing glauconite, pieces of shells, and echinid spines	3·7	„
	Plain level. Total thickness... ...	390·9	metres.

How far below the plain level these Cenomanian beds extend it is difficult to say, but it is significant that the *Hemiaster cubicus* beds are not met with above ground, although in Gebel Ataqa they are found in fair thickness, and these beds are regarded by M. Fourtau (¹) as being the base of the Cenomanian system.

With regard to the different divisions of the Cretaceous represented here, the author is inclined to fix the upper limit of the Cenomanian at the top of Bed 13 of the section, but he has not been able to obtain any characteristic fossils from which to decide whether the remaining beds are Turonian or Senonian. Blanckenhorn (²) found Hippurites in these beds and regards them as representing Turonian and Senonian.

It is certain that the section examined by the author is not identical with that of Blanckenhorn; for whereas that of the latter shows the beds lying in their normal position, in the former from Bed 13 they are inverted as much as 25°. On either side of Bed 13, the beds dip away from each other. As the beds are followed from ground-level from this point they show a gradually increasing verticality, until at Bed 13 they are absolutely vertical; from this point they dip in the other and normal direction at 70°. The cause of this phenomenon is a dip-fault having a bearing of N. 60° E. As the line of fault is passed one can see the beds gradually passing the vertical position and taking up the normal dip of about 45°.

Blanckenhorn (³) is inclined to regard this hill as part of an anticline, but the author prefers to look upon it as a broken inverted dome or basin, the way in which the beds seem to dip from nearly every point of the compass being his reason for this view.

Four kilometres west of the hill of Shabrawet a black knoll is seen which on examination proves to be of Cretaceous age. It differs from Shabrawet in consisting almost entirely of Turonian and Senonian beds. This hill is about 100 metres wide. On the north side is a small ridge more or less separated from the rest by a drainage line; the beds in

(¹) " Contrib. a l'étude de la faune Crétac. d'Egypte." L'Institut Égyptien, 1903, P. 232.
(²) Zeitschr. d. Deutsch. geolog. Gesells. 1901, S. 62; Loc. cit. 1900, S. 37.
(³) Loc. cit. 1901. S. 67.

the ridge dip 70° to the north, while those on the other side of the drainage line dip 30° S., this being apparently a breached anticline. As the drainage is followed up to its head, it is found to rise in Cenomanian rocks which have dips towards S., W., and N.E., of 60°, 15°, and 20° respectively. This is evidently the case of a small dome which further to the east passes into an anticline. The (?) Turonian beds have evidently undergone a very sharp flexure over this dome, as on the north side where last seen they were vertical, while in the opposite limb of the fold the dip was 60°. Further south the dip becomes steeper (70°) and the uppermost chalky beds which contain a gasteropod and pelecypod fauna are eventually covered unconformably by the Upper Moqattam beds. The contrast here between these hills and Shabrawet is great, and represents a great change in physical conditions; for whereas in the former the Upper Moqattam lies directly on the Cretaceous rocks, in the latter there is a big escarpment of Lower Moqattam facing it on the other side of a valley. This is explained in the latter case by a Post-Miocene fault.

Between this knoll and Shabrawet there seems to be a connecting underground ridge which acts as a waterparting and is covered by Pleistocene deposits except in one or two places. This is continuous with the beds in the black knoll, and its beds dip at 30°.

Gebel Ataqa.—The next place where Cretaceous beds were met with is at the east foot of the highest point of Gebel Ataqa. Here there were Cenomanian beds exposed of the thickness of 75 metres. These ran to earth on account of the rise in the ground, due to down-throw beds on the fault-line, but they reappear further to the south, rising high in the cliff on account of a dip of 8° to the S.W. At the foot of the cliff are 60 metres of white limestone which have been thrown down by the fault; they contain no visible fossils by which they can be identified.

As far as could be seen at this place there are 155 metres of Cenomanian beds, of which the following is a general section:—

Top.	Marly limestones without fossils..	45 metres.
2.	Limestone with casts of *Ostrea olisiponensis*; *O. mermeti*; and *O. flabellata*	47 „
3.	Yellow marls alternating with white nodular limestone containing *Hemiaster cubicus*; *Hemiaster* sp.; *Ostrea olisiponensis*; *O. mermeti*; *O. flabellata*; *Cardita* sp., and other pelecypoda. *Conus* sp., and gasteropoda	28 „
4.	Marly limestone containing *Ostrea flabellata*, and *O. mermeti*	35 „
	TOTAL	155 metres.

At the top of these beds are 100 metres of purer limestones, also unfossiliferous, which may probably be Turonian, and from this point the cliff rises vertically for 400 metres, this being composed of Cretaceous and Lower Moqattam beds. In the small wadis coming from the foot of this cliff occur pieces of a coal-black limestone (perhaps a solution vein) which shows sections of organisms. These have evidently come from the Eocene higher up the cliff, as the same rock was found in a mass of that rock thrown down further south.

In the cliff in which the quarry opened by the Suez Canal Coy., occurs, hippurites were found. (1) Of these the author saw none. About halfway up the cliff a reddish band is seen, which when examined was found to be a gypseous bed which has been extensively worked, galleries having been driven into the hill to get out the gypsum which was purest in the middle. This gypseous bed is from 25 to 30 metres thick, and consists of alternating strings of gypsum and yellowish clay, in this resembling the gypsum at Gebel Zet. (2) It has been formed in the same way as the other deposit, viz., by the action of water, as the gypsum is of the fibrous variety in many cases. This bed the author is inclined to regard as the top of the Cretaceous formation, the formation of the gypsum taking place after the submergence under the Eocene Sea. Another reason for this decision is that below the gypseous bed, no Nummulites were found, while immediately above it occur casts of *N. Gizehensis*, and at the top of the cliff there was a bed of those fossils and *Dendracis sp.* There is a dip of 5° away from the cliff bringing the top of the Cretaceous to ground-level in the wadi which comes down from the plateau. In this cliff the thickness of the Cretaceous beds, as above defined, is 380 metres.

The red trace of the gypseous bed on the up-throw side of the fault which occurs in the above-mentioned wadi, can be followed by means of field-glasses along the cliff towards the highest point of Gebel Ataqa. Assuming this to be so in that point, the following thickness may be adopted :—

Top.	Middle Eocene, measured in cliff	155 metres.
2.	Cretaceous limestone in cliff (probably Turonian and Senonian)...	380 „
3.	Cenomanian marls and limestone	155 „
	TOTAL	690 metres.

(1) Q. J. G. S., 1855, p. 59 Pz. 4 ; DOUVILLE, "Etudes sur les Rudistes." Mém. Soc. Géol.. France, 1898, pp. 201-3, pl. 29.

(2) "Topography and Geology of Eastern Desert of Egypt." 1902, p. 195.

This agrees very well with the total height of the cliff.

Blanckenhorn [1] publishes the following statement, viz., that the Campanian composes two thirds of Gebel Ataqa. He further gives the following section going from below upwards:—

Top.	Dolomitic limestone containing *Hippurites vesiculosus*	46	metres
2.	Dolomitic limestone with *Ostrea larva; O. laciniata;* and *Vola sexangularis*	3	„
3.	Alternation of dolomitic and earthy chalk without fossils	221	„
4.	Red marl with gypsum	7	„
5.	White limestone without fossils	50	„

Above this comes Lower Eocene.

All this thickness of beds—327 metres—he regards as being Senonian. Of this he thinks that 49 metres can only be regarded as Campanian, but he also says that perhaps all the dolomitic beds may belong to that stage. He was evidently unaware of the presence of Cenomanian beds in this cliff.

Comparing the thicknesses given here with those obtained by the author it is seen that, after deducting the Cenomanian and the Eocene from the total height of the cliff, there are 380 metres of beds which represent the Turonian and Senonian stages of the Cretaceous. It is difficult to say whether the Turonian is represented here or not, as no fossils were seen in the rocks immediately above the Cenomanian beds. Blanckenhorn has assigned all the limestone seen by him to the Senonian, but as he has not seen the lower beds mentioned in this chapter it is impossible to know to what stage he would have assigned them, and in the absence of fossils the decision must be deferred.

There is no doubt that the cliff of Gebel Ataqa is the remains of a broken anticline the easterly limb having been thrown down partly below ground, as shown by the appearance of the Eocene beds at the foot of the cliff. At the foot of the highest point of the cliff, nothing remains of the downthrow beds except probably their broken fragments preserved in the boulder beds of Pleistocene age lying to the east of the cliff.

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(1) Zeitschr. d. Deutsch. geol. Gesells., 1900, pp. 40-41.

CHAPTER VII.

BASALT.

This rock outcrops at various places in the district under description. It occurs in the form of :—

(1). Volcanic necks ;
(2). Intrusive sheets ;
(3). Lava flows.

(1). Volcanic Necks:—These occur in three places, viz., Gebel Gafeisad or Agleiat Qamr; at a point 11·5 kilometres east of Der el Beda; and at a place to the north of the latter place and mid-way between it and Agleiat Qamr, on the eastern flank of Gebel Gafra.

Gebel Gafeisad:—This is a low conical hill rising out of the surrounding rocks. It slopes gently on all sides except the north, where it falls more abruptly, faulting having taken place. It rises through the Oligocene sands, but owing to the junction being masked by Miocene beds it is impossible to determine whether any alteration has taken place. A curious fact is the presence of a large plug of quartzite or silicified sandstone which evidently occupies the vent, while down one side (the southern) there is a low dyke-like mass of the same rock standing out in relief, evidently representing in both cases the filled-up fissures of an ancient geyser or thermal spring. This occurrence is a clear proof of the relative ages of the basalt and the geysers in this particular case. The rock in this place is a good deal decomposed, so that its character could not be determined with certainty, but it seemed to be fairly fine-grained. No extension of it could be seen, unless the small exposure on the north side of Gebel Gafra issued from this vent. On three sides the Miocene rocks come on to the flanks of the hill, and this may mask the sheet which has issued from this point, while on the other side it has evidently been removed, as the Oligocene sands, which in all cases underlie the basalt, are exposed. It is thus seen from the foregoing statement that the basalt is older than the geysers and the Middle Miocene beds.

Volcanic Neck east of Der el Beda.—The next well-defined volcanic neck occurs at a point 11·5 kilometres east of the ruined palace of Der el Beda. Here it stands up as a black knoll with a sheet of basalt sloping away from it. It consists of about 9 metres of tuff, overlain by 18 to 19 metres of fine-grained basalt. The tuff occurs mainly on the south side of the cone, and this seems to point to this side being nearer the centre of the vent. This deduction is borne out by finding a little further to the south, the basalt coming up through the Eocene limestone and metamorphosing it. At another place a reddish sandstone was seen at the foot of the cone, which is in all probability a piece of metamorphosed Oligocene sand, as beds of that age come close up on this side. The basalt shows columnar structure on all sides, thus pointing to its being fairly quickly cooled.

Gebel Gafra:—Further to the north, about 8 kilometres away, is seen the third basalt neck. It is a fissure in the Eocene limestone up which the basalt has risen; the sharp, vertical walls of the metamorphosed limestone stand above the basalt at the present time, the latter having been denuded away. On the eastern part of the fissure the basalt has been so worn out that it presents the appearance of a trench, the walls of which are formed by the altered Eocene limestone. In any place where the junction between these two rocks is seen, the absolute verticality of the walls is very striking. Enclosed in the basalt are numerous pieces of Eocene limestone; these have in all probability fallen into the vent during the violent stage of an eruption, when the explosions produced by the liberation of steam and other gases, rent large pieces of rock from the sides of the vent. These rocks have undergone considerable metamorphism; they are of a bluish-grey colour, are hard and splintery like glass, and show flow lines. All traces of fossils have been destroyed, while in many cases, a block when broken up shows a seam of ochreous matter in the centre. The rock on either side of this ochreous seam is a veritable "Clinkstone"; it has undergone fusion as evidenced by the lines of flow seen in it. The limestone for a little distance round the basalt has undergone a certain amount of alteration, as the fossils have assumed the bluish gray colour of the altered rock. In many places the basalt is extremely decomposed.

Connected with this neck also, is a large mass of quartzite which is evidently the remains of a geyser; while running off in various directions are dykes of the same material. Here, as at Gebel Gafeisad, the same relations exist between the basalt and the quartzite.

(2). Intrusive Sheets:—The only place where a sheet of this nature is found in the area under description is at the east foot of Gebel Um Thibua which is a continuation of the Ataqa range. Here it has altered the limestone around it for 5 metres from the point of contact. At first it was difficult to determine whether this was not a neck similar to those described above, but after examining the occurrence carefully it was found that the basalt lay between two beds of limestone, both of which were altered by the contact. On the side next to Gebel Um Thibua it apparently rises up a vertical crack, while on the other it was seen to overlie altered sedimentary beds dipping westward. At the outcrops on the east side of the small wadi which lies between Gebel Um Thibua and Ataqa, the basalt seems as if it were rising up from the east. The most likely explanation of these occurrences is that the basalt or dolerite has been brought up in an anticline; this would account for the steeper dip seen in the beds at the base of Um Thibua. This intrusion is thrown underground by the fault which runs along the north face of the hill, but it reappears again further to the north-east. It is interesting to note that, as will be seen by a glance at the map, this intrusion is on a line with the three volcanic necks already described. It also seems probable that it may belong to the same period of eruption as they.

(3). Lava Flows:—The first place where the basalt flow was met with was in Gebel Dhaher on which stands Tower No. 3 on the Old Post Road to Suez. Here it is found at the foot of the hill in a very decomposed state, and overlain by a falsebedded yellow friable sandstone. Further out from the hill the basalt shows a thickness of 7 to 8 metres, and at this point it is thrown down below ground by a fault.

The basalt again reappears at the foot of a series of isolated hills forming an east and west ridge lying about 4 kilometres to the south of House No. 2, Old Suez Road. It lies under the same beds as those seen at Gebel Dhaher. The beds are as follows:—

Top of ridge.	Hard black siliceous sandstone...	1·8	metres.
2.	Yellow sandstones and grits	13·0	„
	Total	14·8	„

Below this comes the basalt, which is 7 to 8 metres thick, is much decomposed, and is full of veins of opal and chalcedony filling up cracks. In many cases the chalcedony stands out in relief, the basalt having been weathered off on either side of it. A little to the south the basalt was again covered by an outlier of similar rocks but differing somewhat from them in detail. The following is a detailed description of these beds:—

Top.	Falsebedded sandstone..	3·0	metres.
2.	Rounded flint conglomerate	0·3	„
3.	Calcareous sandy grit	0·75	„
4.	Lenticles of brittle limestone dying out rapidly	1·0	„

Basalt underlies this, and has an outcrop of about 1 kilometre wide. This rock is undoubtedly the continuation of that seen at the foot of Gebel Dhaher.

About 3 kilometres to the eastward the basalt was again crossed, but it was found that the above-mentioned beds together with the black siliceous sandstone were absent, and a bed higher in the series than the latter overlaid it. This basalt flow outcrops in an east and west line for 10 kilometres. In the absence of the black sandstone and the beds below it, there is a proof of an overlap and unconformability.

El Angobia:—On the north of the Eocene dome of El Angobia on the downthrow side of a fault, a small wedge of Oligocene rocks is laid against the Eocene rocks, being overlaid in turn by a bed of basalt 20 metres thick. It is roughly columnar, and where fresh, is a good, hard compact rock which would be useful for macadamising purposes. Further east another and larger patch of basalt is met with along the fault-line; it is 17 to 18 metres thick and is a good useful rock. This exposure is 1·5 by ·5 kilometres in extent. In all, including the exposures already described, there are 12 different places where basalt was noted in this region, varying in area from the merest hummock to patches measuring 1·5 by 0·5 kilometres.

To the south of Gebel el Angobia another exposure of basalt is found lying against the Eocene in such a position as to show that it has been brought there by a fault. In the country between Bir Gendali and El Angobia which is occupied by a confused mass of conglomerates, sands, and grits of Miocene age, the basalt is seen outcropping in all the wadis. About 4 kilometres east of the foot of Gebel Ali Hamum el Aberaq, and about 6·5 kilometres in a north-easterly direction from Bir Gendali, a small knoll of columnar basalt about 2 metres thick is found at the base of the Miocene beds, and overlying the Oligocene sands. In this region, wherever the Miocene beds have been removed in a wadi the basalt is seen.

Wadi Gendali:—About 8 kilometres below Bir Gendali, there occurs on either side of Wadi Gendali, in small side wadis, what is to be regarded as an injected fissure out of which basalt has at one time issued. Connected with this fissure are the remains of geysers and geyser fissures which are subsequent in age to the basalt. Both geyser remains and basalt have been let into Lower Moqattam beds of the Eocene by a trough-fault. Here the hade of the fault is seen very plainly at one side, its angle being between 70° and 80°. The throw of the fault is not less than 165 metres.

The only other occurrences of basalt are in connection with the denuded stump of the volcano described on p. 71. There, a long narrow tongue appears at the foot of the Miocene escarpment, but its outcrop is extremely narrow. Another patch occurs about 1·5 kilometres south-east of the neck above-mentioned. It is the last remnant of the flow left on the up-throw side of the fault which throws the Miocene down to plain level. Further east beyond Gebel Awebed, no traces of basalt have been met with.

The Age of the Basalt (1):—In discussing the age of the basalts of the Fayum Blanckenhorn (2) puts their age as Oligocene. Those on the Cairo-Suez side of the Nile Valley on the other hand, he considers Lower Miocene, though what his reasons are for this does not appear plainly. He says that the hill-movements and breaking-out of basalts came at or after the time of the silicified woods (Petrified Forest) or almost immediately before the transgression of the Helvetian Sea. This being so, it is difficult to reconcile this statement with another made in his "Das Miocän", where he refers the sands found at the base of the Miocene to the east of Cairo to the same stage as the Mogara Sands, viz.,Lower Miocene. It has been shown by the writer that these sands and sandstones lie discordantly on the basalt, while there is an overlap as well, as shown by the absence of these sandy beds in a section only 2 kilometres away from that in which they were seen. The pouring-out of the basalts was previous to the period of geysers and thermal springs as is shown in numerous sections; but a curious fact must be noted here that, although plugged fissures, up which the heated waters came, exist almost on the edge of the Miocene deposits, one looks in vain for any trace of them in these deposits. If then, Blanckenhorn's correlation of the sands with the Lower Miocene of Mogara be accepted for the sake of argument, and no evidence of geyser action has been seen in them, it follows that the geysers were prior to these sands. If the geysers be prior to the sands, and they have been shown to be subsequent to the basalts, what is the age of the basalt? It cannot be Lower Miocene as Blanckenhorn would make it, but must belong to the Oligocene. This brings the period of its eruption to be practically of the same age as that of the basalts which occur to the south-west of the Pyramids of Giza in the Libyan desert.

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(1) See paper by the author in Geol. Mag. on this subject.

(2) "Das Oligocän," Zeitschr. d. Deutsch. Geolog. Gesells. Jahr. 1900, P. 457 et seq.

CHAPTER VIII.

FAULTS AND FOLDS.

In the area under description, only faults of the normal type are found, while the folding is not very marked on account of its being masked by later deposits, and has been deduced mainly from the small domes laid bare by subsequent denudation.

Faults:—These fall under three heads, viz.,

(1). Strike-faults.
(2). Dip-faults.
(3). Trough-faults.

Gebel Dhaher.

(1). Strike-faults:—This type of fault is the predominant one in this district. Beginning at the west side near Cairo, the first met with is one which is responsible for the formation of the small hill of Gebel Dhaher (1) on which stands the Tower of N° 3 Station, Old Post Road to Suez. Here the Miocene (Helvetian) has been let down against the basalt underlying the Lower Miocene by a throw of 79 metres.

Gebel Ansuri and Gebel el Angobia.

The next place where faults of this type are met, is round the Eocene dome of Gebel Ansuri and Gebel el Angobia. The main fault hades to the north with a throw of 150 metres at its point of maximum displacement, while the fractures bounding it on the west and north have much less throw. Here the Miocene and Upper Moqattam are brought in contact at the point of greatest throw.

Further north and east is one of the main lines of fault, viz., that bounding the gravel ridge on the south on which Der el Beda stands. It begins near Station No. 5, Old Post Road to Suez, and continues east past Der el Beda up to the western extension of the mass of Gebel Awebed where it dies out. The throw where it can be measured is 55 metres. In this case the Miocene is let down against the Oligocene to the west and east of Der el Beda, while near Gebel Awebed this rock is found lying 40 metres below the level of the top of the Lower Moqattam giving a throw of 150 metres. The continuation of this line of fault is evidently that which bounds Gebel Awebed on the south side.

The corresponding strike-fault to the one just described, is the

(1) See Section IV.

north-hading line of fracture which bounds the above-mentioned gravel ridge on the north and is cut off by the dip-fault along which the Wadi Gafra has cut its gorge through the Miocene ridge north by east of Der el Beda. In all probability, the fault which throws down the Miocene to the north of the western ridge of Gebel Awebed, and which bounds that hill on the north, belongs to this line of fracture. Connected to this line of fracture by dip-faults is another north-hading fault. This may, perhaps, be part of the line of fracture seen at Gebel Dhaher, but evidence of the continuity of the two is not visible owing to a mask of downwash. This line of fault is broken by dip-faults at three places, the lateral shift in all cases being to the north, and the displacement as much as 1 kilometre. This fault is lost for some distance under the downwash but is found again further to the east where it apparently cuts the dip-fault of the Gafra gorge. Eleven kilometres north-east of Der el Beda it dies out.

On the other side of the plain or wide valley up which the Old Cairo-Suez Railway ran is another south-hading fracture, also broken by a dip-fault, which brings the Upper Moqattam and the Middle Miocene together on the southern flank of Gebel Gafra. Here the throw is 137 metres.

Further west, in the neighbourhood of Um Qamr a north-hading fault is seen which brings the Miocene and Oligocene together. On the north flank of Gebel Gafra, traces of the same class of fault are found; while to the east of Gebel Gafeisad or Agleiat Qamr it is again seen but dies out before El Gherbe is reached. Beyond this hill it again appears, runs east for 16 kilometres, then swings round to the northeast, and finally seems to lose itself in the plain near Gebel Shabrawet. In reality it is continued in a south-easterly direction along the edge of the cliff bounding the Isthmus of Suez and appears at the foot of Gebel Genefe where the Miocene is thrown down against the Lower Moqattam.

What may be considered as an off-shoot of this main line of fault is the line of fracture which takes its origin at the point where the change of bearing from east to north-east takes place, and continuing eastward finally turns southeast inside the main line and eventually joins it at the northwest corner of Gebel Genefe. This offshoot is in all probability due to the superior resistance of the inlier of Cretaceous rocks which lies like a wedge in the angle formed by the two faults. The several minor faults seen inside (west) of the main fracture form a series of step-faults which reduplicate the outliers of the Upper Moqattam on the plateau to the south of Gebel Shabrawet.

The sudden change of bearing of the faults which may be described as the Isthmus faults, is evidently the result of two earth-movements acting simultaneously and at right angles to one another, the fracture taking the direction which is the resultant of the two forces. It is interesting to note that, in the neighbourhood of the Isthmus only, the two movements have been acting simultaneously, while further to the west the force acting in a north and south line has almost entirely influenced the direction of the faults. Practically the one exception to this rule is the fault on the south side of Gebel Gafra.

Between Gebel Genefe and Awebêd there is a small fault hading north-east and broken by a short dip-fault. In this case it would seem as though the north and south force had been too strong for the other, the dip-fault marking the place where it became paramount and changed the direction of the fracture.

Last of all is the main fault which bounds the district to the south and gives rise to the bold escarpment of Gebel Ataqa, Um Thibua, etc. In Gebel Ataqa the change in direction of the fault as it leaves the Isthmus is very marked indeed. At first it has an almost due N. and S. direction, which, as it is followed up, gradually changes to N.W. and finally becomes almost due west. Here also is seen the meeting of the two faults at the pivot on which the line of fracture has swung round. The reason for this is not so apparent as in the previous instance. It is certain, however, that the more southerly of the two is the main one, and has a throw of 690 metres at its maximum displacement at the highest point of Gebel Ataqa. As this fault is followed towards Gebel Um Thibua it is seen to be replaced by a series of short faults *en échelon* which is eventually replaced by that which runs along the foot of that hill and is doubtless continued along the escarpment to Gebel Qatamia where it turns northwest and then west and dies out to the north of Bir Gendali. It is probable that the last piece of this fault is an offshoot from the main one which dies out and is replaced by the syncline which separates Gebel Tura from Gebel Moqattam.

(2). Dip-faults:—Of this class of fractures only a few, and these only of small importance, occur in this area. These all occur with one exception, in the vicinity of Der el Beda. The most westerly one is seen at the west end of the gravel ridge on which the ruined palace stands. This shifts the strike-fault a few hundred metres to the north; the next, going eastward, produces a shift of one kilometre; while the third makes a corresponding movement at the Middle Station on the Old Cairo-Suez Railway. Another occurs in Gebel Gafra. That which occurs in the Wadi Gafra gorge has shifted the Miocene escarpment 2 kilometres to the north. The only other fault of this type occurs about 7 kilometres to the north-east of Gebel Awebed where a lateral shift of 300 metres has taken place.

(3). Trough-faults:—Only one well-defined fault of this type is known in this area, viz., that ? kms E.N.E. of Bir Gendali, where Upper Moqattam beds are let into the Lower Moqattam. Here the throw is 165 metres. The part where the dip-faults occur to the west of Der el Bêda may be regarded as being formed by a trough-fault as the hades of the bounding fault are towards each other. In this case the faults are not simultaneous, but have evidently been produced one after the other.

Age of the Fractures:—Regarding this the only writer who, to the author's knowledge, has assigned an age to the faults is Dr. Blanckenhorn. This writer (1) says that, prior to Miocene times, the Eocene was faulted, Gebel Ataqa, Awebed, Genefe, and Abu Terifia were formed and the Miocene was laid round their bases in a reef-like manner. With this statement the author cannot agree, and it is only necessary to examine Section I., to see that as far as Gebel Genefe is concerned the evidence is conclusively in favour of a Post-Miocene age for the fault. It is impossible to explain the occurrence of the beds at such a difference of level except by a fault. Even in the case of Gebel Awebed and Ataqa the evidence is all in favour of the Post-Miocene age of the fracture. In the former there is direct evidence for it (see Section II); while in the latter the indirect evidence is all in favour of the fault being Post-Miocene. If, as Dr. Blanckenhorn affirms, the fault took place in Pre-Miocene times, there ought to be denuded Eocene rocks with the Miocene lying unconformably, and overlapping on them. Such is not the case. What is actually seen is the Miocene dipping away from the cliff, underlaid by the Oligocene, which in turn is underlaid by the Upper Moqattam. This lies at the foot of the Lower Moqattam cliff, while only in one place is this stage of the Eocene seen on the downthrow side. All this points only to one conclusion, viz., that the fault is Post-Miocene. It does not matter where evidence is looked for, it always points in the same direction. In the broken syncline between Gebel Genefe and Ataqa, the Miocene is seen to conform to the fold in the same way as the other rocks.

But although the age of the faults is undoubtedly Post-Miocene in all cases, it can be shown that all of them were not produced at the same time. Take for instance the places where the dip-faults occur.

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(1) Zeitschr. d. Deutsch. Geolog. Gesells. Jahr. 1900.

Here it can be shown that the northern strike-faults are older than the dip-faults, because the latter break and displace the former; while the south strike-fault is younger than all. It can also be seen from the map that the strike-fault on the north side of the gravel ridge on which Der el Beda stands is younger than the three dip-faults to the west of that place, but older than that on its east side. Similarly it can be deduced that the strike-fault that lies on the north side of Wadi Gafra gorge is younger than the dip-fault along which that gorge is formed.

Folds:—If the study of these be commenced from the east side, it will be seen that, although there are two sets of folds to be recognised, those having a N.W.-S.E. axis dominate the others whose axis lies in a general E. and W. line. It would seem as though Gebel Shabrawet were the pivot on which the axes swing round, and a S.S.W. line through that hill seems to mark the line of node where the two folds interfere with each other. East of that line all the folds lie on N.W.-S.E. axes; while on the west they lie on E. and W. axes.

Taking the first set, Gebel Genefe and the plateau to the north-west, as well as Gebel Ataqa, and the subsidiary folds between all belong to that group. To the second set belongs the majority of the folds. Of these the most important of those visible are those which stretch from Gebel Shabrawet through El Gherbe to Gebel Gafeisad, Gebel Gafra and the plain to the west; the gravel ridge on which stands Der el Beda with its extension in Gebel Awebed; the western half of Gebel Ataqa, Gebel Um Thibua, etc., and further west the dome of Gebel el Angobia and Ansuri with the ridge which bounds the Petrified Forest in the north.

The movements which have given rise to existing folds have been described by the author in a paper (1), and in the Chapters on Miocene and Eocene.

This district is interesting from its furnishing support to the theory put forward by Professor Lapworth in an address to the British Association for the Advancement of Science, 1892, to account for the origin of the geographical features of the earth. In this area one sees first the evidence of the trough of the earthwave in the Lower Moqattam; of the advance of the following crest in the Upper Moqattam; and of the presence of the actual crest in the Oligocene period. In the Miocene period, evidence of the following trough is again visible in the shallow-water beds of the Lower stage and the deeper-water conditions of the Helvetian or Middle Stage.

(1) Geol. Mag. 1904, P. 604.

CHAPTER IX.

RELIEF OF THE GROUND.

It may be laid down as an axiom that, other things being equal, in a plateau or other level expanse of new land recently raised above the level of the sea, the amount of relief in any one part of it is inversely as the hardness or compactness of the beds composing it. This would be true for all land lying above the level of the sea were it not that other influences are continually at work modifying in some cases and accentuating in others the normal sculpture of the land. It is the purpose of this chapter to show how the sculpture of the area under consideration has been modified by what may be termed the extraordinary agents of sculpture. In differentiating between the normal or ordinary and the abnormal or extraordinary agents of earth sculpture, it may be here stated that the author regards water in the form of rain or torrent as the only normal agent and prefers to regard the others, to be enumerated later, as abnormal. It may be objected that wind and sand have an equal right to be considered as normal agents, but the reply to this is that the whole of the sculpturing was done by the water during the Pluvial period immediately preceding the present arid one, and that therefore these must be regarded as belonging to the category of influences which are now at work modifying the work of the water.

The agents which are responsible for the present relief of the area under description are :—

(1). Water,
(2). Faulting and folding,
(3). Wind and sand.

(1). Water.—If it be granted that the period at which the sculpturing really began was the time when the land rose in Upper Moqattam times, then the evidence for the carving by water is very strong indeed, equally in the presence of the sands and gravels of the Oligocene, and in the absence of a great thickness of beds as shown in the chapter on the Eocene. No evidence of wadis or drainages can be shown, because if any existed they are covered by the late deposits ; but it is inconceivable that any other agent than water did this work.

During the later periods the same remains true of the water. In soft rocks such as the Oligocene sands and the Miocene beds, it is not to be expected that evidence of great carving such as is seen in the wadis in the older rocks will be forthcoming, as the sides of the drainages are worn away almost as fast as the bed is cut out, especially when the older Eocene beds are reached. Such a country does not lend itself to picturesque sculpture, but the resultant is a tumbled, confused mass of gravelly mounds as in the case of the Oligocene and Lower Miocene, or of alternating dip-slope and escarpment in the Middle Miocene, except, where in a few instances a ridge has been breached along a crack or fault-line, when a sheer-sided gorge is the result. Such an instance is seen where Wadi Gafra breaches the Miocene ridge of Der el Beda. In no other part of its course does this wadi show any scenery, except at Bir Gendali where, on account of hard beds in the Eocene, its sides are strikingly terraced and small waterfalls occur in its bed.

It is, however, where there is different hardness of beds that the sculpturing by water is shown at its best. The foregoing examples show this; but no better example of this can be seen than in Gebel Shabrawet and the few Cretaceous inliers near it. This hill stands up as an island between two drainages, each of which has cut its way through the softer and more recent beds, leaving the more resistant older rock standing up like a watch-tower. Other good examples are Gebel Awebed, the dome of Gebel el Angobia and Ansuri, and Gebel Moqattam.

(2). Faulting and Folding.—It is, however, to this agency that the boldest features of this area are due; to this also the water owes its potency in numerous instances, for unless there had been a departure from the general dead level, the latter agent would have been powerless. The bold, frowning escarpment of Gebel Ataqa, the gentler cliffs of Gebel Um Thibua and Qatamia, the striking "horst" of Awebed, the abruptly-ending plateau of Gebel Genefe with the steep-scarped tableland to the north of it, all owe their origin to this agency. The curious step-like appearance seen in different places on the plateaux among the ridges of this area also owe their origin to faulting or folding. This has been shown in the Chapter on "Faults and Folds."

But it is to this agency also, coupled with the peculiar composition of the beds themselves, that the wide plain, along which passes the Old Post Road to Suez, owes its origin. It is bounded on the north by a fault which has let down the Miocene, and this, having weathered down to the sandy conglomerate beds at its base, formed a gravel-covered plain. The wide valley along which passed the Old Cairo-Suez Railway also owes its origin to similar causes. The breaking up of the Miocene formation into isolated ridges and scarps can also be traced to the same cause, while these have been very much modified subsequently by sand and wind erosion.

Although it has been stated in the previous paragraph that the dome of Gebel el Angobia and Ansuri is exposed by a process of differential erosion, its presence is primarily due to folding accompanied by faulting. If this had not taken place, these hills would in all probability, be still under the newer formations. Gebel Moqattam also primarily owes its origin to a combination of these two movements, its position being accentuated later by differential weathering and water erosion.

(3). Wind and Sand.—It is in this district, however, that the action of these agents is best seen. Here there is a greater difference of hardness between the Older and Newer Tertiaries, than exists in other districts between the Secondary and Older Tertiary rocks: in consequence of this the work of wind-borne sand is much more evident. This is especially so on the Miocene rocks. On these, in many places, curious appearances such as a false dip-slope, or a series of what appear to be parallel ridges with the beds apparently dipping under the ridge in front are produced, which are likely to lead the unwary geologist into erroneous conclusions. It is only by following these ridges up for some distance until they are found to merge into a low plateau or by collecting the fossils from the different exposures and comparing them carefully that the observer can preserve himself from error. Such a series of ridges is seen to the south of House No. 2 on the Old Suez Post Road, about 9 kilometres from Cairo. To the west of Um Qamr a different type of ridge (1) is seen. Here the surface of the low plateau is formed of a hard bed which has apparently had cracks running more or less parallel to each other along which the sand, driven by the southwest wind, has carved out little valleys. The deception is kept up by the appearance of a dip-slope on the northern extremity where the beds apparently dip into and disappear under the plain. Further to the east, the hard bed is grooved and furrowed in a wonderful manner by the sand between Um Qamr and Gebel Gafra and on that hill itself.

On the south flank of this hill another good example of the false dip-slope and ridge is seen (1). Here it occurs on the downthrow side of the fault, and the angle of dip of the slopes is 22°. It was only by

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(1) See Sketch Section VI., Sketches Nos. 1 and 2.

looking for palaeontological evidence that the author was saved from falling into the trap here set for the unwary observer.

Turning to the more extensive evidences of sand erosion, it may be pointed out that the ridges on either side of the low valley up which the old Cairo-Suez Railway passed owe their gentle slope to this agency.

The mass of Miocene limestone lying between El Gherbe and Gebel Awebed, which presents a steep escarpment to the north–east, and a gentle dip-slope to the south, owes the latter to the work of wind-borne sand, the general southwest and southerly winds with their burden of sand having planed off the edges of the beds until they appear as if dipping into the plain. It is perhaps the most distinctive feature of the Miocene area, this gentle slope to the south with the corresponding steep scarp in the opposite direction. On the surface of these slopes some wonderful fretwork is sometimes met with in the soft limestone, at times exhibiting most fantastic forms.

There is no doubt that this area is an ideal place for seeing the eroding power of sand. All the conditions are favourable for it; the sand is obtainable from the Oligocene beds which are always exposed near by; there are wide plains or open country facing the direction of sand-carrying wind, which allow the latter full scope when travelling at a good rate; in fact the rocks here are exposed to a veritable sand-blast.

Beautiful examples of differential sand-etching are met with wherever the consolidated sand and gravel, which occurs near the fissures of the ancient thermal springs, is exposed. In these, the pebbles are often seen standing out from the general mass like ungainly warts on the body of an animal. Excellent examples of differential wearing and structure are seen in the hard plugs of thermal springs which stand out on the surface of Gebel Gafra like huge ant-hills. In these the different hardness of the cementing silica is well shown by the harder layers standing out in relief; the unequal layers of the sand are also well brought out by the false-bedding exposed by the etching. This leads up to the occurrence of those peculiar-shaped stones named "Dreikante" by German geologists.

Dreikante.—In an area such as this it is to be expected that many examples of these stones which owe their shape to sand-blast should be found. Such is the case; and a few observations made by the author may be of interest to the reader. The following remarks apply to the limestone dreikantes only. There are many forms of dreikante to be met with, and after studying them for some time it appeared to the author that all of them could be explained on very simple principles. After examining these stones in a peculiarly good place where all stages in their production might be seen, three types were recognised which owed their form, firstly, to their original shape, and secondly, to their orientation with reference to the sand-carrying wind. If the original stone be rectangular in form and have its long axis in the direction of the sand-drift it yields a true dreikante; if, however, the long axis be at right angles to the direction of drift, the windward side is polished and worn, while the leeward side becomes covered by the vermicular markings (so commonly seen on the surface of limestone blocks in the open plains of Egypt) and a lopsided dreikante is the result. In the third where the original form is more or less square in plan, and one of its angles is facing the sand-drift, it eventually becomes rounded and a dreikante of a different type is the result. Specimens of these types are to be seen in the Geological Museum, Cairo.

With reference to the direction of the wind which carries the sand, piles up the sand-dunes, and does the erosion, the author has come to the conclusion that the general opinion held, as far as he can ascertain from publications and conversation with different people, is erroneous. This idea is that it is the prevailing wind—N.N.W.—which produces the sand-dunes and carries the sand, but the author's observations lead him to a different conclusion. Dr. V. Cornish (1) in his paper on the sand-dunes round Ismailia put forward the suggestion that the south-west wind was probably the carrier while the prevailing wind acted rather as a sorter and kept the surface and edge of the dune more or less in a line based on the observations of the dunes, the actual observed transport of the sand, and the fact of the eroded surfaces of the rocks facing towards the south, and the grooves on the hard rock lying in the direction of S.S.W.-N.N.E. One has only to travel across sand-dunes in a southerly wind to understand the discomfort from the flying sand, while with a northerly wind of apparently equal strength the air remains clear. The wind which, according to the author's observations, does the main work of sand transport and erosion is primarily, that from the south and southwest, secondarily, that from the southeast, very little from the northeast, while from the north and northwest none at all. This is borne out by the alignment of the dunes in a general N.N.W.-S.S.E. direction—that of the prevalent wind. This is at right angles to the direction of the sand-carrying wind, as it ought to be. Again, the long gentle slope of the dune

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(1) Roy. Geogr. Soc. Journal 1897.

faces the direction of this wind, while the abrupt slope which is always on the leeward side of a dune, and has been shown to be the angle of rest of the sand composing the dune, always faces the northeast. There are, of course, exceptions which seem to vitiate this conclusion, but these can generally be explained by a local eddy, or draught through a confined space. In the open plain where no local conditions interfere with the wind the dunes always conform to the above rule.

In the early part of 1900, the author had a good opportunity of making observations on the sand-dunes of the Libyan Desert while on a traverse between the Fayum and Mogara. On the way there, a long line of dunes was crossed, which was evidently the continuation of those met with farther to the south. The bearing of this line was that of the prevalent wind–N.N.W.–and this remained constant all the way to Mogara, the road lying between two parallel lines of dunes. During this traverse abundant opportunities were afforded of studying the behaviour of the sand towards the winds from different points of the compass, and it was noticed in every case where there was a dense sandstorm that the wind came from the southwest. It was this that first suggested to the author's mind the possibility of the occasional southwest wind being the carrier of the sand instead of, as at first sight might appear, the prevalent wind.

It is now possible to shortly summarise the points in this chapter;—

(1).—The salient features of this area are produced by three agents, viz, Water-erosion, Faulting and folding, and Wind-borne Sand.

(2).—The first agent is responsible for the general levelling of the area; the second for its bold and rugged features; and the third for the gentle, rounded outlines of the district as viewed from the south-west.

(3).—Differential hardness in some of the foundations give rise to local features such as terraces, waterfalls, etc.

(4).—The sand-carrying wind is from the southwest, and not the prevailing N.N.W. wind as generally supposed. This is shown by the orientation of the sand-dunes, the planed-down surfaces of the rocks facing that direction, and the direction of the long slope of the dune.

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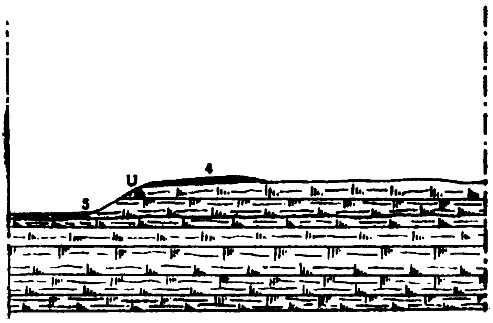

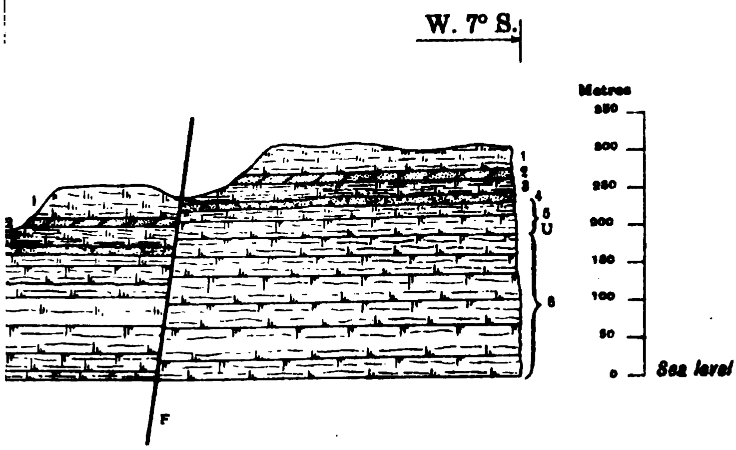

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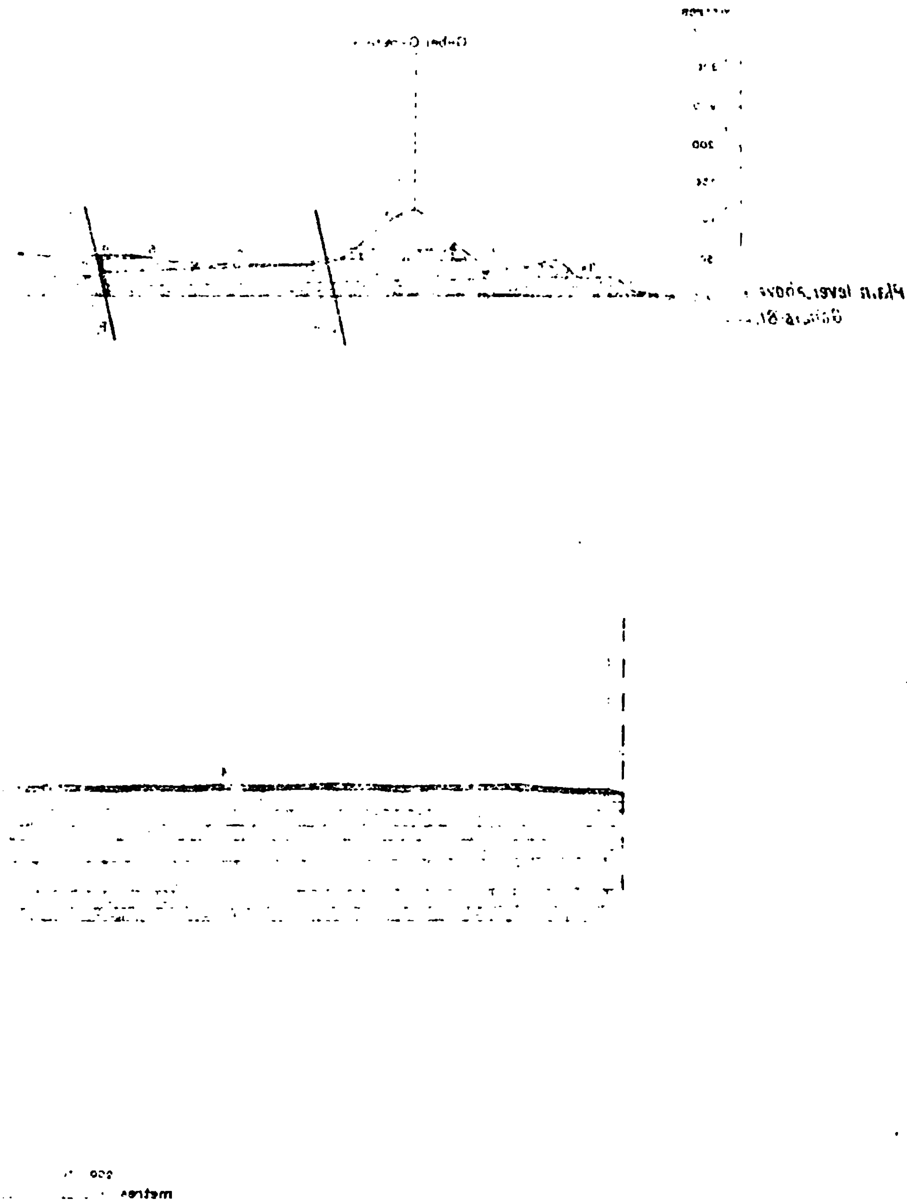

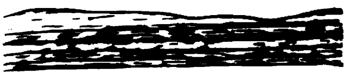

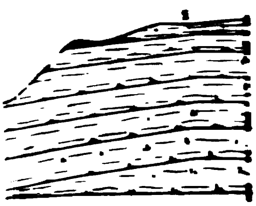

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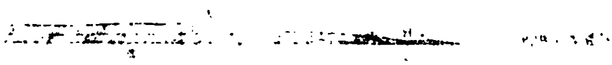

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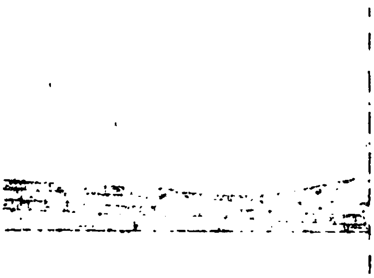

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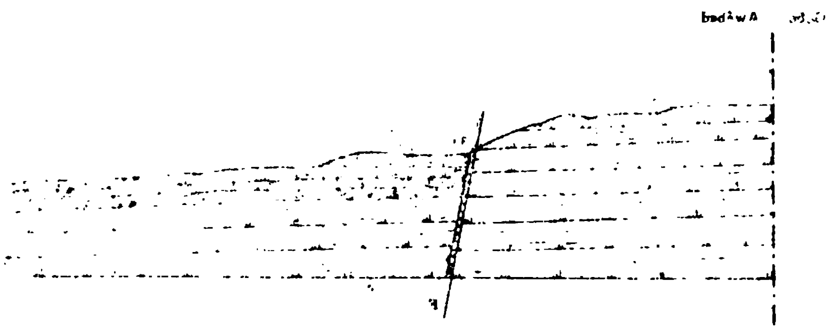

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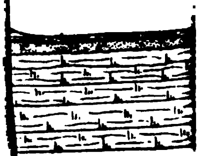

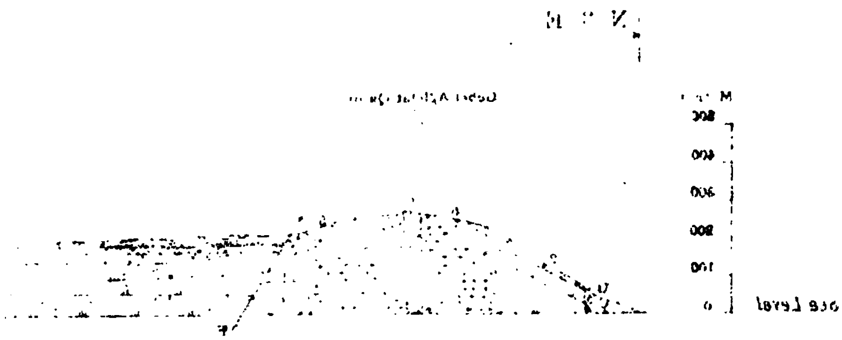

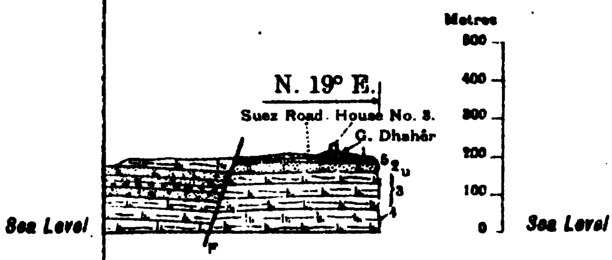

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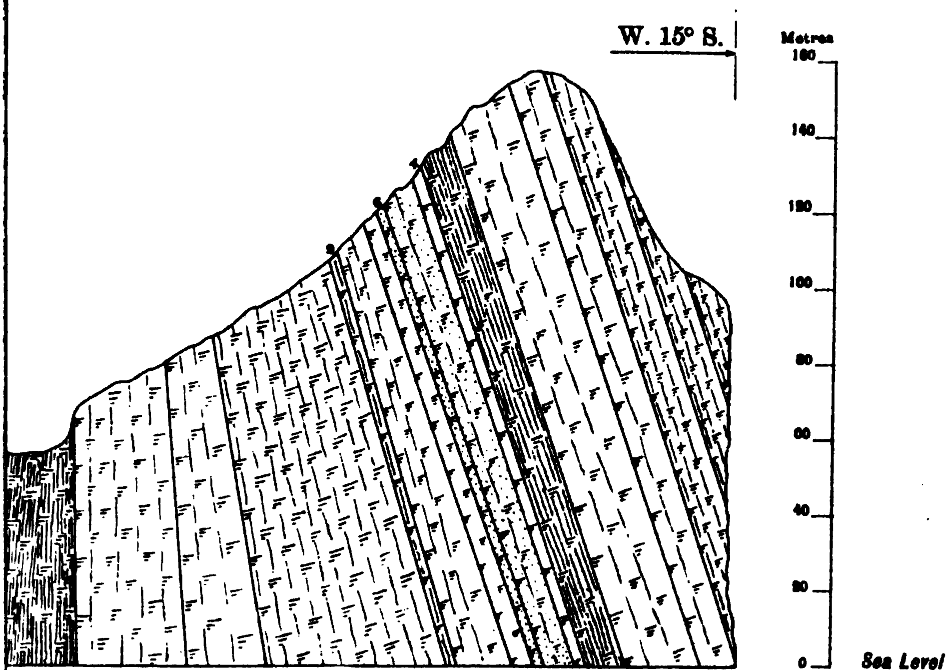

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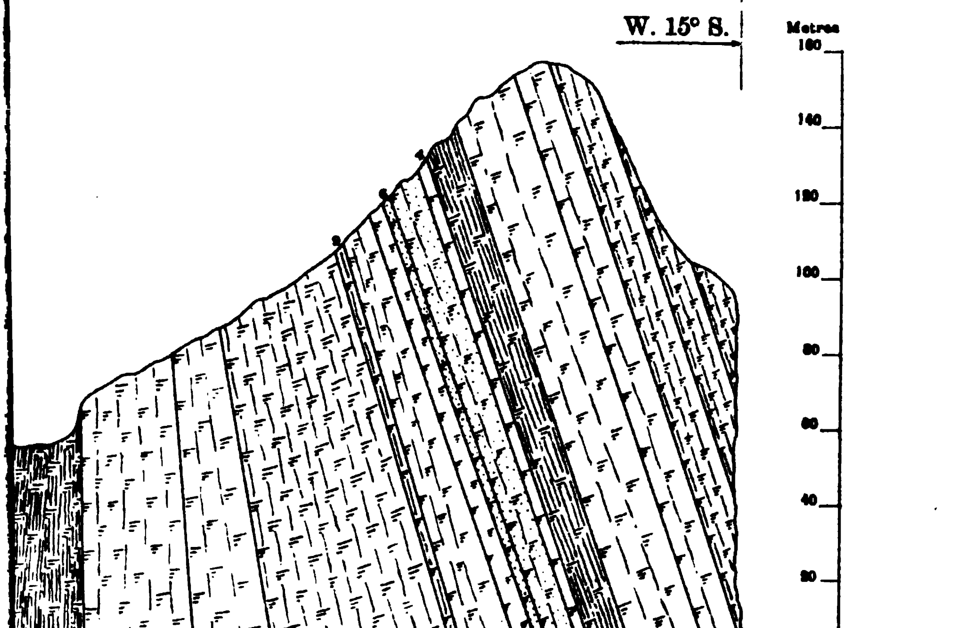

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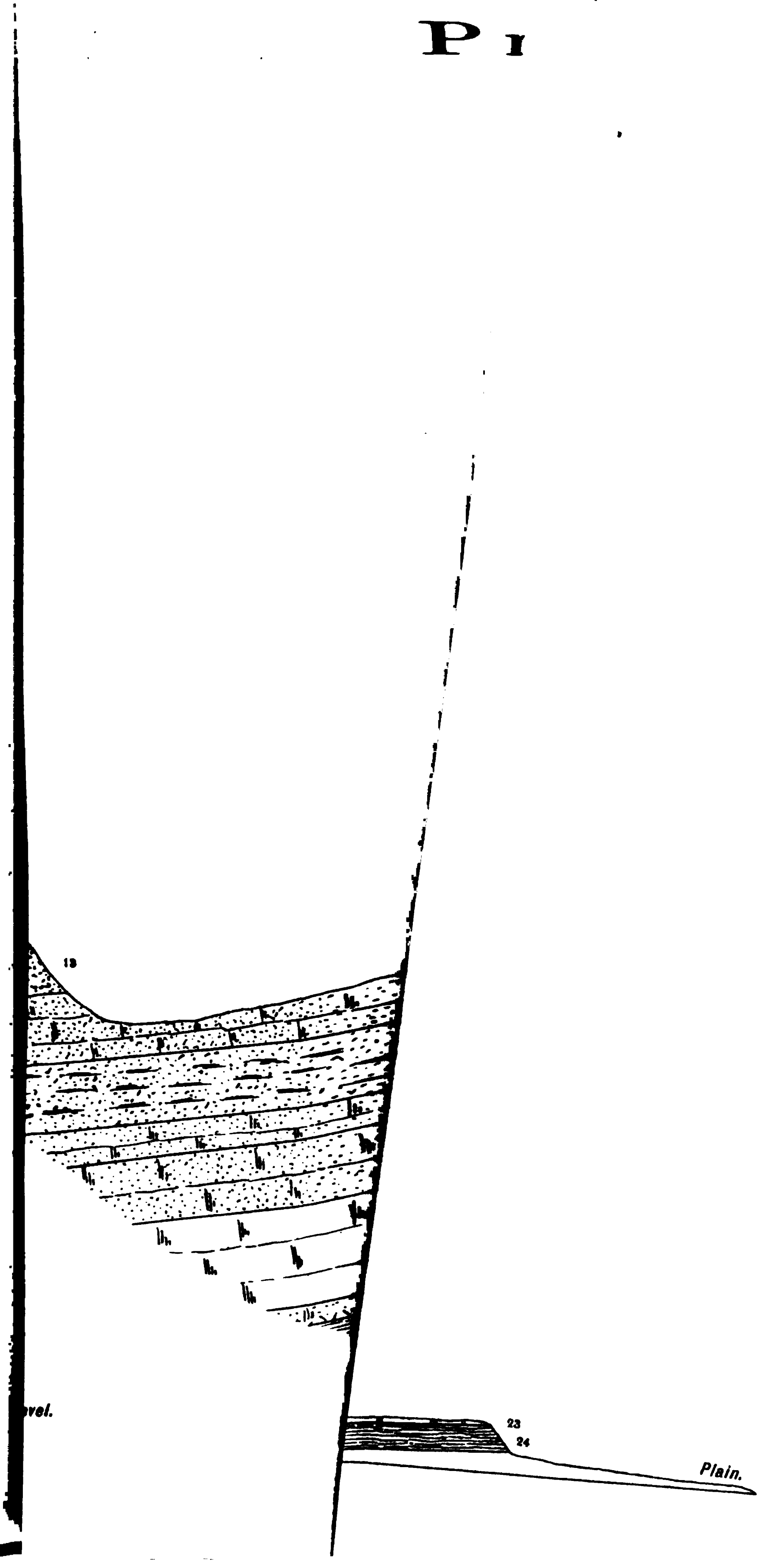

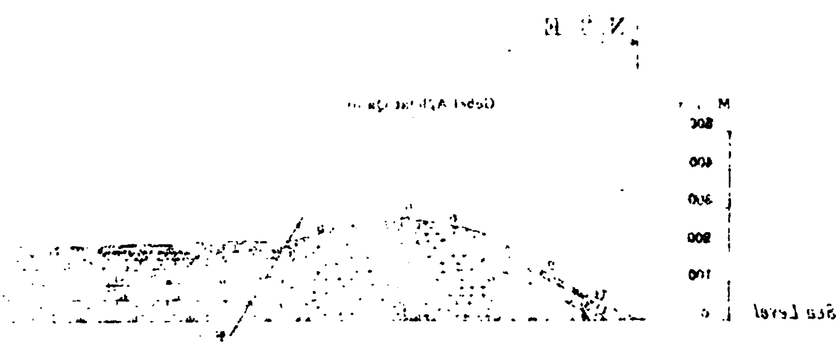
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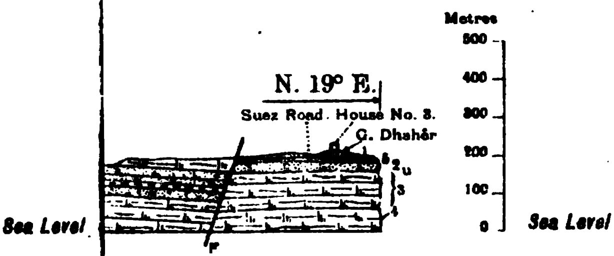

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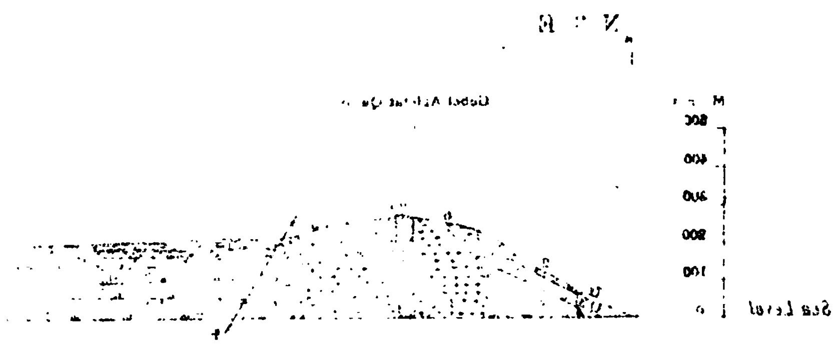

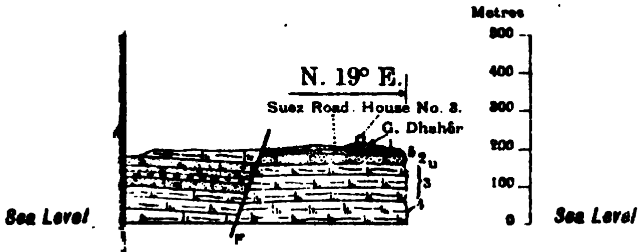
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